PD-ABN-511

COMPLETION REPORT

AGRICULTURAL TECHNOLOGY TRANSFER PROJECT (ATT)

FY 1985-1990
AID. PROJECT NO. 493-0337
AID. LOAN NO. 493-T-036

PROJECTS DIVISION, OFFICE OF THE PERMANENT SECRETARY,
MINISTRY OF AGRICULTURE AND COOPERATIVES

Introduction

This publication contains the final reports of Agricultural Technology Transfer (ATT) Sub-projects completed since 1988 when the completion reports of the first 10 completed sub-projects were published. The ATT Project (USAID Project No. 493-0337) is a cooperative project between USAID and the RTG and is administered by the Projects Division of the office of the Permanent Secretary of the Ministry of Agriculture and Cooperatives. The ATT project had been extended to September 1992 but will be suspended because of US law related to coups on 23 February 1991. USAID and the RTG have added new funds to the project each year. The total amounts as of 30 September 1991 are US $ 5,908,912 Grant and US $ 7,993,495 Loan of USAID funds.

The objective of the ATT project has been to identify, acquire and adapt new Agricultural Technology for use by Thai farmers and the private sector to increase exports and farm income. Although ATT Financial support has ceased for the sub-projects included in this report, they continue to be supported by the RTG budget. In addition to this formal completion report, ATT projet results are passed to the public and private sectors through workshops, seminars, and sub-project bulletins and publication.

CONTENT

1. Sub-Project Title : **Control of Aflatoxin in Agricultural Products. (003)**

2. Responsible Agency : Seed and Post-Harvest Pathology Group, Plant Pathology and Microbiology Division, Department of Agriculture

3. Life of Project : 1985 - 1989

4. Approved Budget :

Loan	US $	154,440
Grant	US $	40,300
Total	**US $**	**194,740**

5. Actual Expenditures :

Loan	US $	143,049	
Gant	US $	18,909	
Total	**US $**	**161,958**	**or approximately 86% of approved budget**

6. Summary of Problem and Objectives :

A. Problem :

Prior to the sub-project there was a serious problem with aflatoxin contamination in maize, sorghum and peanut which affected the export trade of the country as well as posing a serious hazard to domestic animals and the people. During 1981-82, Thailand exported 3,090,680 tons of maize valued at about US $ 450 million. A goodly portion of the shipments were subjected to severe price cuts due to high levels of aflatoxin.

It was estimated that Thai maize alone was discounted by about US 10 dollars per ton in the world maket or about US 30 million dollars in 1981/82

Department of Agriculture with ATT assistance carried out post-harvest field trials, export sampling, analysis and inspection procedures, practical handling techniques for maize and peanut to prevent aflatoxin contamination were introduced to the private sector for use after practical field trials. Improvement in sampling, analysis and inspection methods were also undertaken.

B. Objectives :

1. Reduction of levels of aflatoxin in maize, sorghum and peanut.
2. To test at the farm level "crib" type driers for maize
3. To test mechanical drying of maize,

7. Accomplishments :

1. Improvement of aflatoxin problems in corn

1.1 Research on Crib dryers with ATT funds was conducted using no-cost United Kingdom expertise. Cribs that were effective in Africa were tried. Results showed cribs to be unsuitable for the wet conditions in Thailand. (Corn is harvested in the rainy season).

1.2 A solar heat crib dryer was constructed. Maize of several different moisture contents was stored at various thicknesses in the crib. Ambient Temperature and that inside the cribs were recorded. It was found that the temperature difference inside and outside the cribs were not great enough to create sufficient aeration to stop aflatoxin formation.

1.3 Ammonium polypropionate was treated to corn before storage in the cribs. Results showed that there is no problem of aflatoxin and insects during 4 month storage. (But this is not an acceptable solution because of cost.)

1.4 The use chemicals to control aflatoxin in corn : Eleven chemicals were tested for effectiveness in controlling aflatoxin; 9 chemicals aimed to prevent aflatoxin while the other two were for detoxification. Only ammonium polypropionate can prevent aflatoxin and ammonia gas can be used to detoxify 50% of aflatoxin in corn for feed. But both methods are costly and impractical.

1.5 Drying

1.5.1 Field drying. When corn could be left to dry in field after full maturity there is no aflatoxin problem. The top part of the corn plant can be cut off (Topping) when farmers want to start planting the second crop and corn which is topped will dry quickly. But the main crop is harvested in the rainy season.

1.5.2 Mechanical Dry. Four kinds of fuel were tested for mechanical dryers, maize cobs, diesel oil, LPG and small pieces of wood. Results showed that cost/unit of using cobs as fuel was lowest (7 Mechanical dryer : mc 20% down to 14% 8 ton/hr.) but operation costs were higher than the other three kinds of fuel. The germ of maize kernels dried by corn cob fuel became black and heat not being well dispersed caused many cracked kernels. Wood fuel gave highest return per unit of drying. All information from each dryer test was transfered to the private sector for consideration on aflatoxin control. It is expected that high efficiency dryer will be made locally and accepted by local traders which can be used to assist in solving the aflatoxin problem.

1.5.3 Drying on concrete floor. Kernel drying on a concrete floor costs less than any other procedure and the maize has quite good quality. Aflatoxin can be formed easily in broken grain.

1.6 Developing of aflatoxin analysis methods. Quick screening method was developed by BGYF test and chemical analyses using ELISA which gave accurate confirmation of the presence and quantity of aflatoxin.

1.6.1 BGYF Test was studied to relate number of BGYF particles to level of aflatoxin concentration. Standard color slides were also developed to lessen risk from false interpretation.

1.6.2 Chemical analyses were improved to mimimize cost of chemicals and time spent which still gave 85% recovery.

2. Varietal differences in aflatoxin formation in sorghum was studied and the results showed no differences between varieties. Chemical control was also studied and ammonium polypropionate and thiabendazole can prevent formation aflatoxin but this is impractical.

3. Control of aflatoxin in peanuts was studied by management of insect and plant diseases control and fumigation. After harvest peanuts should be dry within 24 hrs then stored in vacuum polypropylene bag for up to 4 month.

8. Benefits :

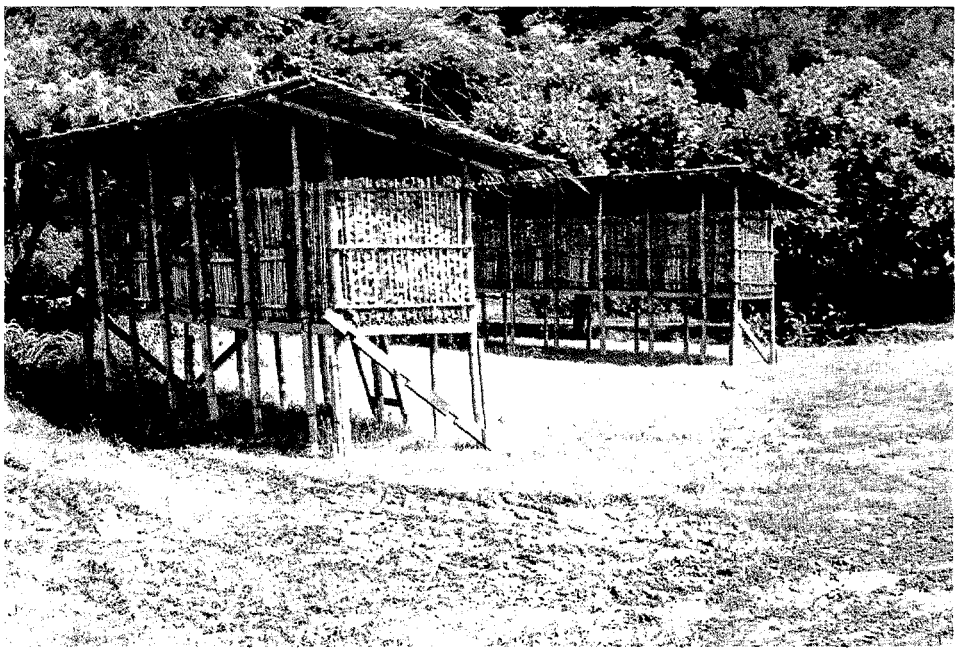
1. A training the trainer program was held for officers from Department of Agricultural Extension, Department of Agricultural Co-operatives and Thai Maize and Produce Traders Association. Twenty individuals were trained and have been assigned to transfer this technology to farmers, local middlemen and other persons involved in aflatoxin control.

2. Two Kasetsart University lecturers were trained in Mycotoxin analysis procedures to improve their teaching and research.

3. Identification of mycotoxins was taught to officers from Department of Livestock Development.

4. Four training courses on aflatoxin identification and control was held about 30 participants from export silos, feed mills and quality control survey companies attended.

5. Determination of aflatoxin by BGYF and Minicolumn was explained to 30 officers from Department of Agricultural Extension and Department of Agricultural Co-operatives so they would know the recommended practices to minimize aflatoxin in maize.



Test crib–type dryers for maize to prevent aflatoxin contamination

The use of Ammonia to control aflatoxin in corn

The use of Ammonia to control aflatoxin in corn for feed.

1. Sub-Project Title : **Quality Improvement of Fresh Fruit and Vegetables. (004)**

2. Responsible Agency : Seed and Post-Harvest Pathology Laboratory Plant Pathology and Microbiology Division, Department of Agriculture

3. Life of Project : 1985-1989

4. Approved Budget :

Loan	US $	321,617	
Grant	US $	132,186	
Total	**US $**	**453,803**	

5. Actual Expenditures :

Loan	US $	279,118	
Grant	US $	99,246	
Total	**US $**	**378,364**	**or approximately 85% of approved budget**

6. Summary of Problem and Objectives :

A. Problem :

In Addition to increasing farm income directly, the export of fresh fruit and vegetables earns a large income for Thailand which helps to solve the unfavorable balance of trade. However, the export of these products is not as great as it should be eventhough the volume is large. This is because farmers and exporters lack knowledge of producing, handling, storing and packaging. In addition, there is insufficient cooperation between the government and private enterprises to improve markets, transport systems, airport facilities, trade organization as well as to solve many problems of legal procedures concerning export.

B. Objectives :

1. To accelerate the improvement of fruit and vegetable to attain the quality demanded by foreign markets and the export volume required to enter foreign markets.
2. To improve packaging techniques so that the packages would be neat and elaborate enough to attract buyers suitable for each type of produce; and improve the storage and transport situation both within and out of the country.
3. To transfer technology for maintaining produce quality as well as packaging practices according to 1 and 2 above to both farmers and exporters.
4. To expand foreign markets of fruits and vegetables in Asia, Europe, the USA and the Middle East.
5. To encourage both government and private enterprise to co-operate more closely to improve production, marketing, storage, trade and transport for export as well as to solve problems of legal procedures of export.

7. Accomplishments :

Mangosteen

Carbaryl 30 g/20 1, carbaryl + benomyl 10 g/20 1 and carbaryl + thiabendazole 15 g/20 1 were sprayed on mangosteen trees from flowering stage to harvesting time at 14 day - intervals. Fruits from sprayed trees showed less insect damage and fewer gum drops on the fruit surface. After two weeks storage at 17-18°C, 90-92% R.H, no significant differences between fruits from sprayed and unsprayed trees were found in the case of fruit rot, translucent flesh and gum deposits inside

the fruit. Not more than 5% of fruit rot were found on the fruit harvested by mechanical harvesting equipment. Results of shrink wrapping were not good because of failure of the shrink wrapping machine itself. Wrapping retail packages with stretch film could keep mangosteen fresh for 10-14 days in low temperatures. Dipping fruit in TBZ (500 ppm) and storage in a cold room (9-10°C) for 4-5 weeks did not increase or decrease fruit rot or calyx mould on the fruit.

Mango

Fruit rot diseases control of mango during storage at 11-12°C, 94-100% R.H. was studied. In Rad mango variety, dipping fruits in hot benomyl (500 ppm.) 55°C, 5 min. or dipping in benomyl (500 ppm.) before vapour heat treatment and packing in polystyrene foam tray wrapped with PVC improved disease control for 3 weeks. In Nang Klangwon mango variety, during 2-3 weeks the treatment of hot benomyl and packing in foam trays was the best followed by benomyl 500 ppm. + VHT and TBZ 500 ppm. + VHT + foam trays. Two weeks after storage, the residues of benomyl and TBZ were below accepted safty levels. In Nam Dork Mai mango variety, fruit treated with hot benomyl followed by prochloraz and packing in PVC wrapped foam tray could be kept for 5 weeks with few discase symptoms.

Sweet Orange

A shipping trial of sweet orange to Denmark by sea was successful by using a fungicide and waxing before packing. The results showed that after 30 days ocean transportation the fruit was still fresh and ready to be consumed. Experiments in the laboratory were storing at 5°C, 90-100% R.H. After 5 weeks storage, the fruit was in good condition, skin still green, and no fruit rot diseases except in the control treatment without fungicides.

Button mushrooms

Button mushrooms were transported from the Northern provinces of Chiang Rai and Chiang Mai by cold truck and by car. Mushrooms transported by car were packed in foam boxes cooled by crushed ice. After reaching Bangkok, the mushrooms transported by the cold truck were fresher than the ones transported by car. After storage in a cold room (3-4°C, 90-95% R.H.) for 5-7 days, the colour of the mushrooms became darker but the cap was still unopened. Packing in a foam tray wrapped with various kinds of plastic film had both good and bad effects on the quality of mushrooms. Mushrooms packed in paper bags and plastic boxes showed cap opening about 10-12 days after storage.

Straw mushrooms

Keeping straw mushroom at 16-17°C, 95% R.H. packed in a carton lined and covered with paper and plastic sheets does not prevent cap opening and production of spores. Transporting straw mushrooms by cold truck (17°C) and by car (34-35°C) from the field to laboratory: Quality of mushroom were checked the day after storage at 17°C about 15 hours showed 5.5% and 28.41% of clongation and cap opening; 1.5% and 0.74% of weight loss were found in mushrooms transported by car and by cold truck, respectively. Storage life of mushrooms packed in PVC wrapped foam tray and stored at 17°C and 12.2°C only one day. After one day, the mushrooms became soft and watery. Straw mushroom packed in a carton had a longer shelf-life but some became mature (cap opening) after 2 days storage. Mushrooms have a short shelf life.

Khai Banana

Control of postharvest diseases of Khai Banana: The bananas were sprayed with benomyl or Thiabendazole 500 ppm. concentrate and whole bunches covered with plastic bags. The bananas were harvested 3-5 days before treatment. After dehanding, the crowns were sprayed with 500 ppm. of fungicide (benomyl or thiabendazole). Packing the bananas in plastic bags with an ethylene absorbent. The bananas were stored at room temperature (15°C for 40 days). Ripening the bananas by calcium carbide 10 gm per each hand for 2 nights. The bananas showed normal ripening, tasted good and were in good condition.

Papaya

Preharvest treatment of papaya by spraying the fruit with fungicide (thiabendazole 500 ppm.) and covering the fruit with paper-bags was done. The fruit were harvested when they showed about 5% red color. Post harvest treatments were dipping the fruit in a mixture of hot water and fungicide (55°C + 500 ppm. thiabendazole) for 15 minutes. Storage of papaya was at room temperature 17-18°C, 95-100% R.H. for two weeks. The papayas were in good condition at end of the period.

Yard long bean

Treatment :

Harvesting the yard long been 1-2 days earlier than usual. Precooling using cracked-ice. Storage at room temperature, 4°C, for 25 days. The yard long beans were fresh and green after treatment.

The post harvest diseases of yard long been are ***Aspergillus*** sp., ***Penicillium*** sp., ***Colleto-trichum*** sp. and several bacteria.

Asparagus

The two best methods of storing fresh asparagus for 4 weeks were to keep it in unperforated polyethylene bags in water at 1-2°C and 85-90% R.H.

To improve quality of fresh asparagus precool by contact icing during transit. However, rotting was a serious problems at high temperatures during storage and export. Some soft rot was caused by fungi (***Fusarium*** spp.) and bacteria (***Erwinia*** sp.) the used of sodium hypochlorite 200-400 ppm. to wash asparagus reduces percentage of rot.

Research is being continued find the best precooling methods. Packing for export in pyramidal boxes with wax covering; each box holds about 5 kgs. of asparagus.

Baby corn

A study storage methods found that baby corn packed in foam trays wrapped with PVC (polyvinylchloride) film could be kept for up to 3 days, 7 days and 2-3 weeks at 29-30°C, 17°C and 5°C, respectively. Baby corn can easily lose quality, particularly moisture and sugar decreases rapidly. A serious problem during storage was postharvest diseases such as ear rots (***Helminthosporium maydis, Fusarium*** spp., ***Rhizopus*** sp.), storage rots (***Aspergillus*** sp. and ***Penicillium*** sp.), smut (Ustilago maydis), and some bacterial diseases.

For quality improvement of baby corn precooling by topicing and forced-air cooling were not effective. Using cartons holding approximately 4 kgs, the standard size for export, we are studying precooling methods to find the best one for export. We also study effects of some varieties of baby corn upon their quality, storage life and resistance to diseases. The experiments will be carried with RTG funds.

Cauliflower

Storage of cauliflower by wrapping each head with PVC (polyvinylchloride) film and packing in perforated polyethylene bags kept in a cold room at 17°C and 2°C about 7-10 days and 4-5 weeks, respectively, for precooling by force-air cooling was better than no precooling.

Rambutan

Careful harvesting and immediate reduction of field heat, including appropiate packing in PVC film for storage at 10°C can prevent rambutan hair turning black in storage for a two weeks. A fresh Golden rambutan variety was tested for export to Switzerland; frozen fresh fruit were shipped by air to Japan. It was found that the Golden variety was prefered in the market compared to the Long Rean variety. This is because of the attractive color yellow hair, not easily turning black, softer embryocarp, a little bit more tart, and larger size. Especially after freezing, they still showed an attractive color, unlike the Long Rean variety which turned gray. In 1987, export demand was greatly increased but export quality rambutan still were insufficient to meet demand.

In 1988, a new wrapping plastic film cryovac PV 7 was tried by wrapping a 2.5 kgs. package of rambutan and sent by sea freight abroad. At the destination, the produce was still fresh with a high quality, by resing after 3 weeks at 13°C in a container.

In 1989, several fungicides were tested for controlling diseases, especially fruit rot. Results still are being evaluated.

Pineapple

Fungicides : benomyl and Thiabendazole 1,000 ppm. were used for protecting pineapple from fruit rot. Paraffin polyethylene based wax (Stafresh 7055) of varying dilutions from 1:5 to 1:9 were used to prevent chilling injury. The results showed that both fungicides could control the fruit rot; wax dilution 1:5 gave the better results than 1:9. Furthermore the combination of fungicides and wax resulted in good quality fruit kept at 10°C for 30 days.

Passion fruit

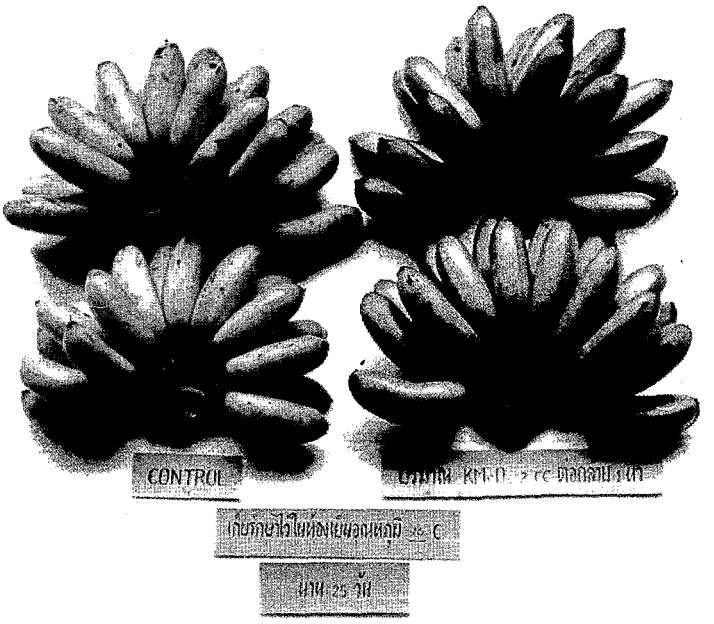
A study on postharvest diseases of passion fruit found that a serious problem was caused by ***Botryodiplodia*** sp. Preliminary experiments indicated that the disease could be controled by dipping the fruit in certain kinds of chemicals such as benomyl, imazalil, thiabendazole or sodium hypochlorite. The imazalil tended to be more effective than the other chemicals. However, further experiments will have to be done with RTG budget.

Applying a wax coating helped to extend storage life of pineapple; chemicals used were Sta-Fresh 320 (FMC crop) and Pservax 551 (Four quarters Ltd.).

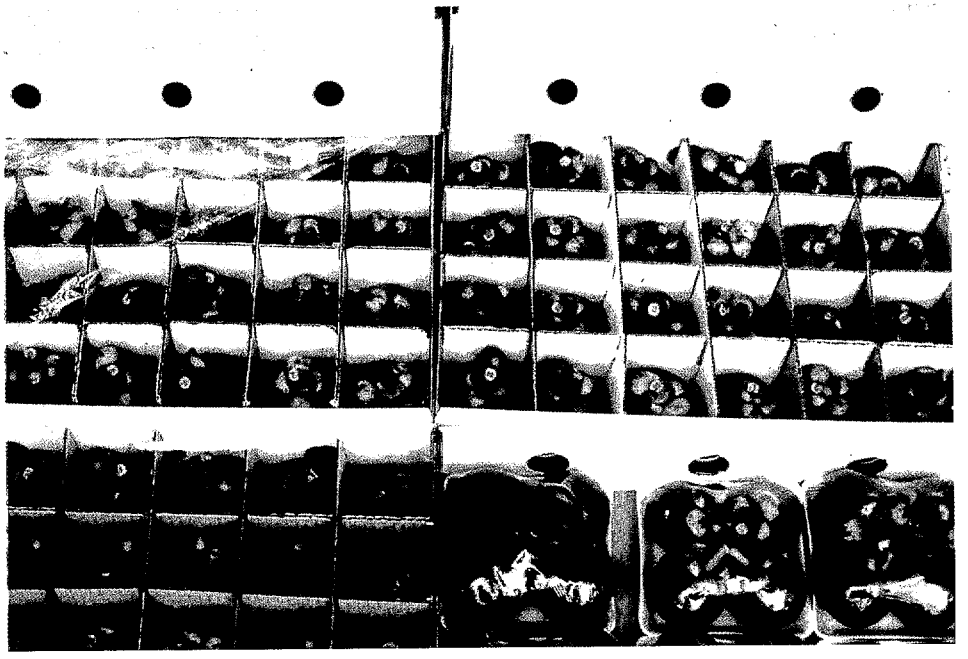
Technology Transfer (1986-1989)

1. Eleven seminars and exhibitions on "Quality Improvement of Fresh Fruit and Vegetables for Export" were arranged for private sector training on fruits and vegetables for export at various locations.
2. Four seminars on "Quality Improvement of Mangosteen and Rambutan for Export" were held for the farmers at Chumporn, Suratanee and Nakorn Sritamarat provinces.
3. Seminar on "Technology of Producing and Export Vegetable, Fruit and Orchids" was held on September 9, 1988 for the private sector.
4. Training on "Postharvest Handling of Horticultural Crops" was held for lecturers of the Institute of Technology and Vocational Education.
5. Training on "Postharvest Handling of Khai Banana for Export Shipment" was held 2 times at Tak for the private sector.
6. Lecturers were provided to join seminars and discussions on held by others on related topics of fruit and vegetables for export.

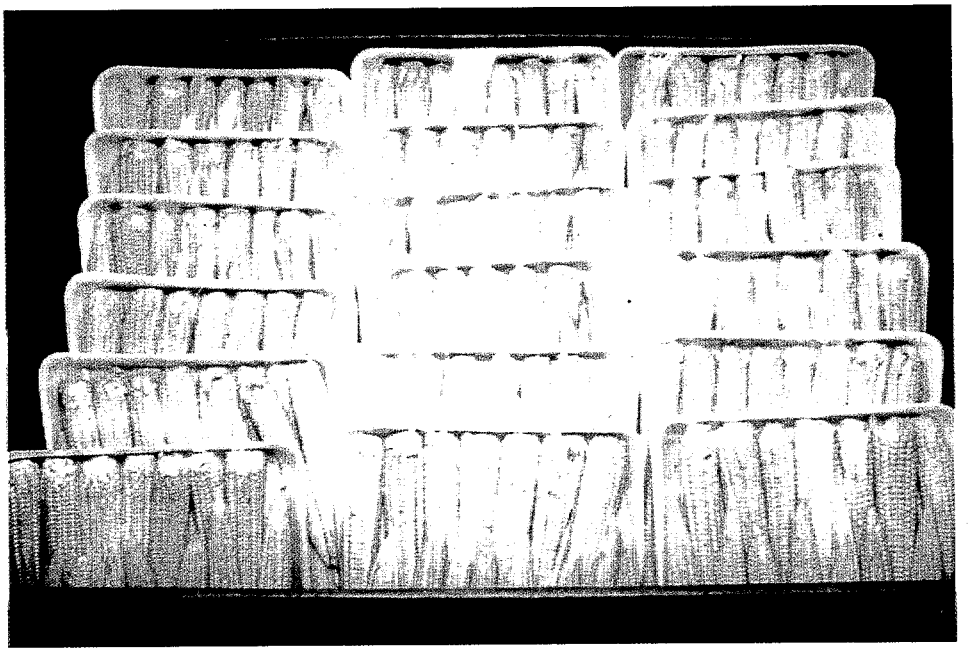
Quality improvement of Khai Banana for export



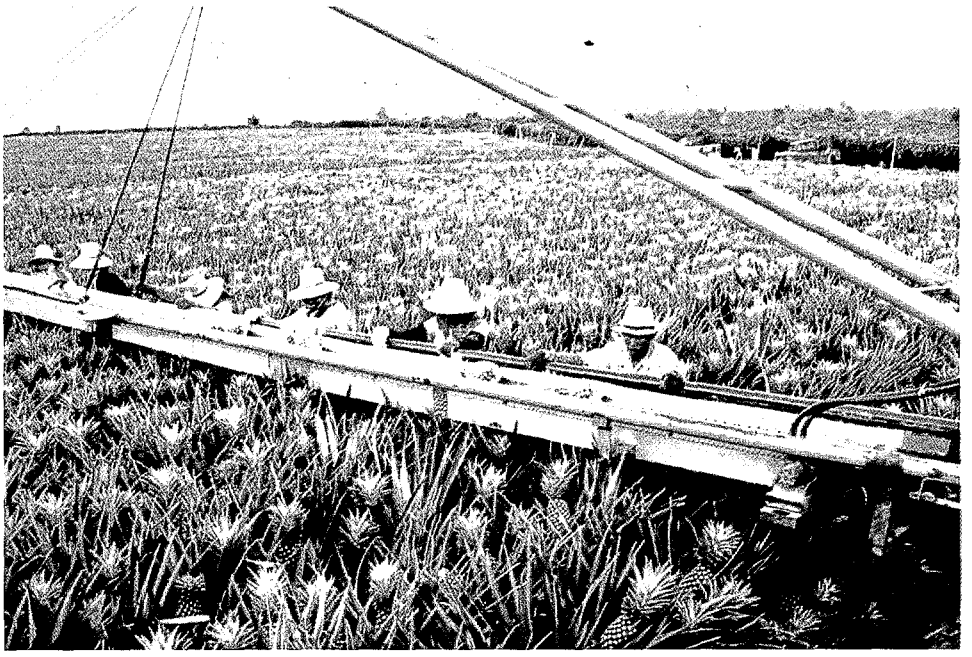
Using chemicals to slow the ripening of Khai Banana



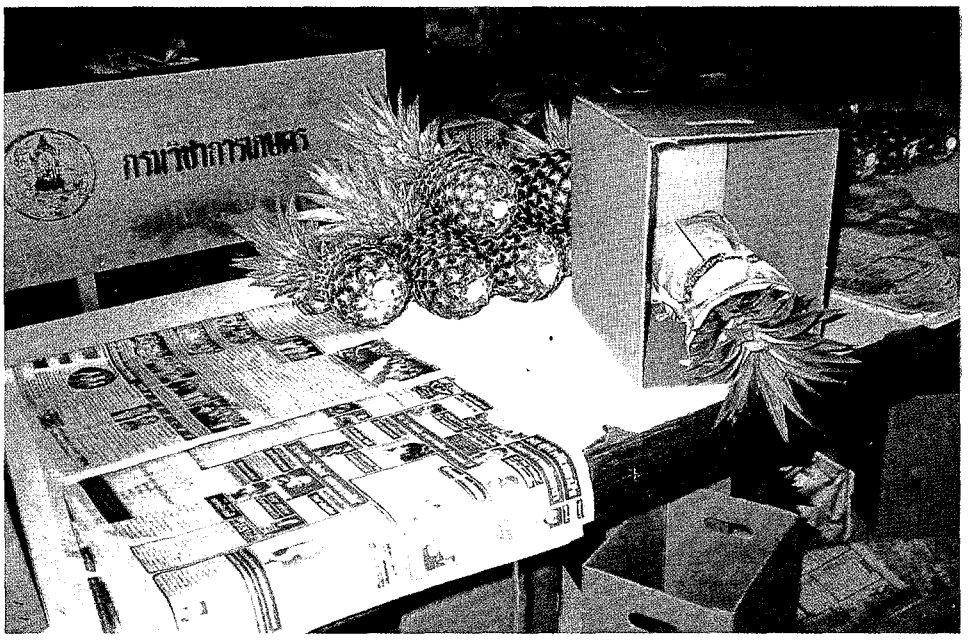
Various methods of mangosteen packaging for export



Baby corn packaging for export

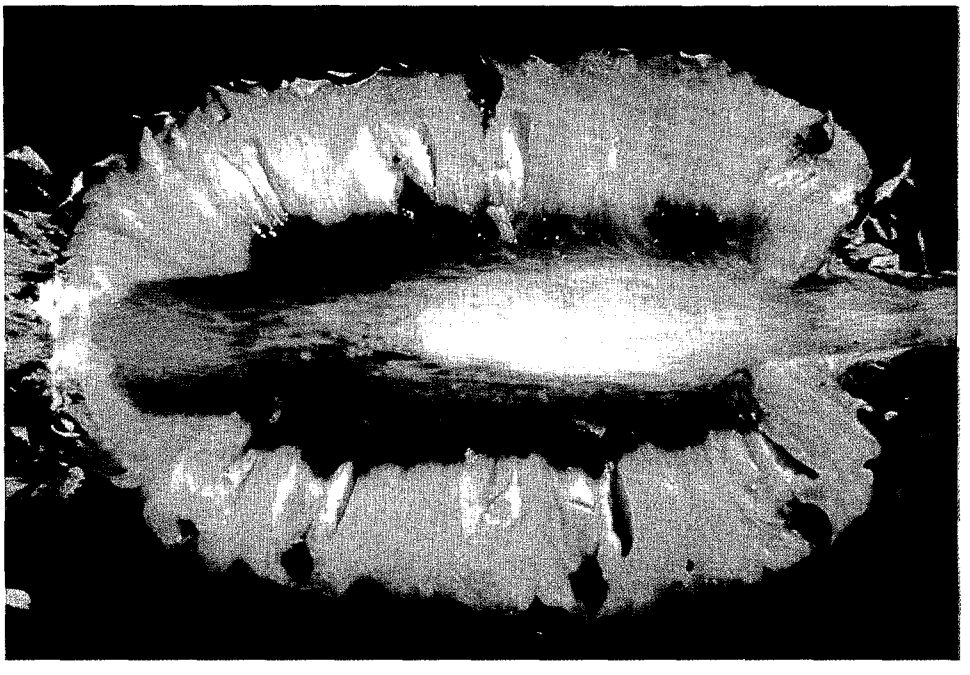


Pineapple harvesting using mechanical conveyor.



High quaility pineapple is being packaged for export

Quality improvement of pineapple by pre – cooling



Poor quality pineapple due to the incorrect cultural practices.

1. Sub-Project Title : **Black Mungbean Contamination with Macrophomina Phaseolina. (005)**

2. Responsible Agency : Plant Pathology and Microbiology Division
Department of Agriculture

3. Life of Project : 1985-1989

4. Approved Budget :

Loan	US $	62,453
Grant	US $	5,954
Total	**US $**	**68,407**

5. Actual Expenditures :

Loan	US $	55,800	
Grant	US $	5,954	
Total	**US $**	**61,754**	**or approximately 90% of approved budget**

6. Summary of Problem and Objectives

A. Problem :

Black gram (***Vigna mungo*** L. Hepper) or Mung Bean is widely grown as a second crop after corn, cotton or soybean. Most black gram seeds produced in Thailand are exported. Japan is the biggest importer, each year Japan buys around 40,000 - 50,000 tons (valued at 24 million US dollars) from Thailand for bean sprout production. Before the sup-project started the importers informed Thailand that seed quality of black gram was poor; the seeds were contaminated with ***Macrophomina phaseolina*** and other fungi. Contamination was not acceptable because the quality of bean sprout is lowered and may be hazardous to the consumer. If this problem could not be solved, Thailands black gram would lose the Japan market.

B. Objectives :

1. Monitoring of fungi contamination of black gram seed production cycle from planting to shipping.
2. Improving farm practices and handling techniques after harvesting.
3. Finding a new variety which is better than the local variety. (non-recumbent).

7. Accomplishments and Recommendations for Farmers and Private Exporters.

To control ***Macrophomina phaseolina*** in black gram seed, the following practices are recommended :

1. Prepare the field for planting by ploughing the land and plant in rows instead of broadcasting the seed.
2. U-Thong 2 variety is recommended instead of the local variety, because it has the bigger seed and an erect stem (non-recumbent).
3. Postpone the planting period from August to September or October, this will reduce the infection percentage in the seed.
4. Drying: different types of drying were tested; drying on a tarpaulin floor, on a bamboo mat, gathered in piles the field, hanging and drying on the ground. It was found that drying on the tarpaulin is better than the other methods.
5. Threshing, in cooperation with the Division of Agricultural Engineering using a thresher for black gram seed have been demonstrated to farmers in the main growing areas.
6. Seed treatment: six seed treatments were tested on ***Macrophomina phaseolina*** such as thiabendazol (pronto), Benomyl (benlate), thiophanate-methyl (topsin M), carboxin + thiram (vitavax + thiram), mancozeb + orthocide (dithane + orthocide) or orthocide (captan) using 1, 2 and 3 xa. i/kilogram seed. It was found that benomyl (benlate 50%), Thiophnate-methyl (topsin M) or thiabendazole (pronto) at the rate 2, 1.5 and 2.5 gm./Kg. seed are effective in controlling the fungi.

7. Before exporting black gram seed they should use a gravity machine for controlling the quality of the seed (poor seed is separated out).

8. Benefits

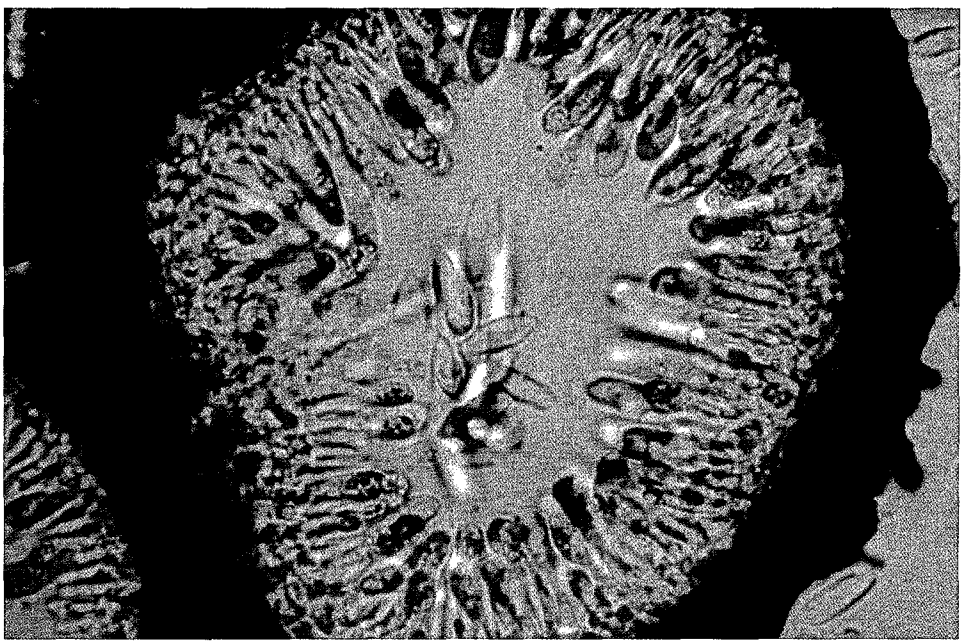
Training Activities : To transfer the new technology for controlling ***Macrophomina phaseolina*** in black gram seed, the following measures were carried out:

8.1 Four seminars were held at Kampaengphet and Phitsanulok province. About 1,050 persons attended from the cooperators of the Department of Agriculture Extension, the Thai maize and Produce Traders Association, including associated offices and the private sector also attended.

8.2 Thirty tons of good seed varieties were exchanged for local varieties for planting 6,000 rai, financially supported by the Farmer's Aid Fund.

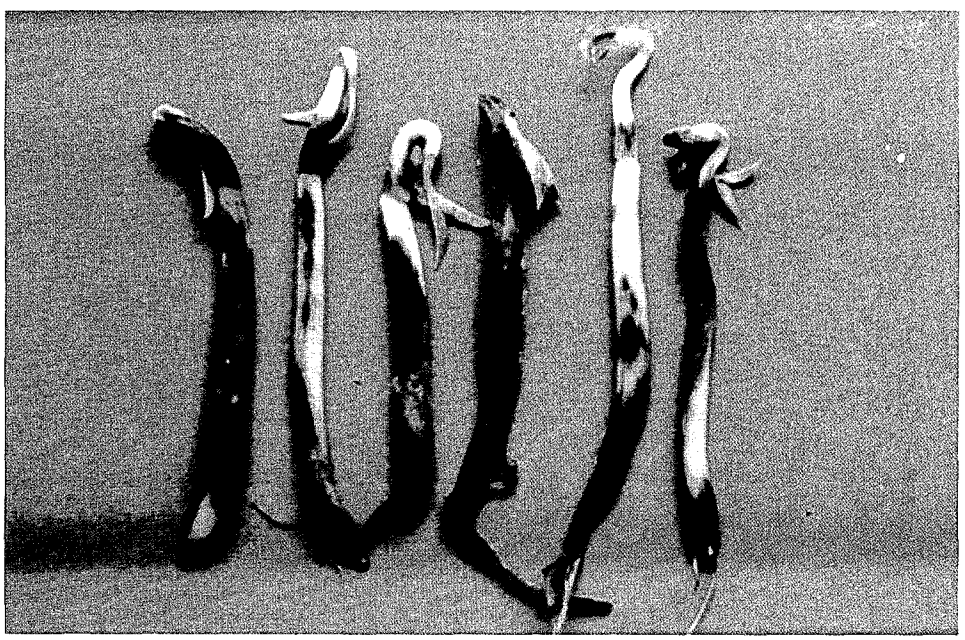
8.3 Field tests of Black gram seed for export at Sukhothai and Phitsanulok 150 rai with the supplemental fund from the Japan Bean Sprouting Importers Association.

8.4 Black gram demonstation at Phitsanulok Field Crop Expertment Station for 120 farmers.

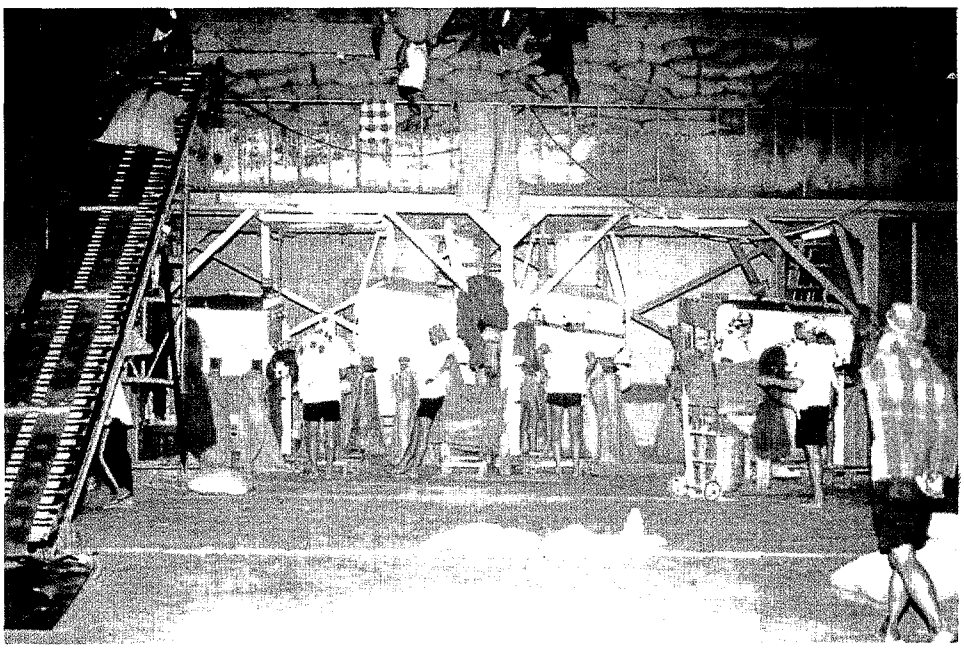


Macrophomina phaseolina spores.

(Enlarged 200 time)



Macrophomina phaseolina on the mung bean sprouts.



Quality grading system for mung been by specific gravity machine before export.

The symptoms of Macrophomina Phaseolina on black mungbean in the field.

1. Sub-Project Title (006/2) : **Using Technology to Improve Fish Quality and Develop New Fishery Products for Export (Phase II)**

2. Responsible Agency : Quality Analysis and Research Section, Fishery Technological Development Division, Department of Fishery

3. Life of Project : 1989-1990

4. Approved Budget :

Loan	US $	345,035
Grant	US $	87,874
Total	**US $**	**432,909**

5. Actual Expenditures :

Loan	US $	333,111	
Grant	US $	5,604	
Total	**US $**	**338,715**	**or approximately 78% of approved budget.**

6. Summary of Problems and Objectives :

A. Problems related to raw materials and their utilization :

1. Prices of fish used to produce surimi and crab-analog have increased because they not only are a raw material of dried and smoked, salted and fresh for food but a large amount are used for surimi for export. But the price of raw surimi fluctuation up and down with export demand.

2. Crab-analog production problems :
   - construction delayed due to several waivers required.
   - to improve the sanitation of surimi took time; different fish species were tested.
   - to use the facilities for food manufacture standard freezers, water facilities, electricity, ventilation, air cleaner, packing unit, cold storage, waste water treatment all had to be improved.
   - insufficient main power had to be increased.
   - procedures for microbiological testing were set up.
   - it took 2 months to fill up the land on which the crab plant is located.

B. Objectives :

1. To develop new fish products.
2. To improve the surimi and crab-analog production processes for export.
3. To study other species of fish to substitute for thread-fin bream.
4. To show interested private sectors how surimi and crab-analog was produced.

7. Accomplishment :

A). General

- Modern fish technology has been rapidly trasfered to Thai private sector and products developed such as raw surimi and surimi finished products.
- By-catch fish are almost all utilized not only for minced fish (SURIMI) but also for many traditional Thai Food Products.
- The quality of the by-catch fish or smaller sizes of fish has been improved at all stages of the processing chain.

B). Technical Activities :

1. Using technology to improve the factory line process for better quality of surimi products :
   - Varied the production of fish to water.
   - Time and temperature variations during washing surimi.
   - Determining the proper washing speed.
   - Improving surimi color and gel formation ability before and after adjusting the washing temperature.
2. Studying on the crab-analog machinery functions :
   - Studying and practising how to use the crab-analog machinery for optimum quality.
   - Study the crab-analog quality produced from difference quality surimi and difference fish formations.
3. Making the crab-analog :
   - Formulated crab-analog products after consumer acceptability tests were made.
   - Identify the crab-analog properties (chemical, physical) microbiological analysis and organoleptic evaluation of the crab-analog after processing and keeping under difference situations (time and temp.)
   - Determine the shelf-life of the crab-analog.

C). Technical Assistance :

- Prof.Dr. Chong Lee (Food Technologist)
  Univ. of Rhode Island U.S.A.
  for app. 10 days.

8. Training Activities :

1. Demonstration and technology transfer.

- There were 16 visitors from MFRD/SEAFDEC of Singapore on Post harvest technology, 2 Malaysians, 2 Phillipinos, 2 Brunie, 2 Japanese, 3 Thai, 2 Indonesian and 3 Singaporians.
- Demonstration on crab-analog production.
  304 participants :-
  102 private companies represented
  160 government officers,** university professional students,
  42 mass media, radio broadcasting and interested people.
- Crab production was demonstrated to 12 participants from China.
- A video tape on crab-analog production was aired by Television chanels 5, 3, 7 and 11.
- The pilot plant is also used for study by university students from Chulalongkorn, Kasetsart, Srinakarainthaviroj and Lardkrabang.
- Exhibitions and demonstrations on surimi production and crab-analog production will be held at the pilot plant, Bangpueng phra-pradaeng, Smuthsakorn periodically expecting 200 participants per show.
- Marketing promotion on crab-analog was held in Chaingmai on 17 - 23 May 1991, by cooperated with Rincome hotel, and also with Chaingmai Orchid hotel. It was found that all customers Thai and foreigners were interested and provided information which will be useful to DOF.

** *Government Officers : Medical Science, Dept. of Science and Service, Thai standards Institute (TSI), Dept. of Agriculture FDA-DOA-AG.CHEM., Consumer Protection Agency, Board of Investment (BOI), Thai Institute of Science and Technology Research (TISTR).*

9. Benefits and Recommendations :–

A). Benefits

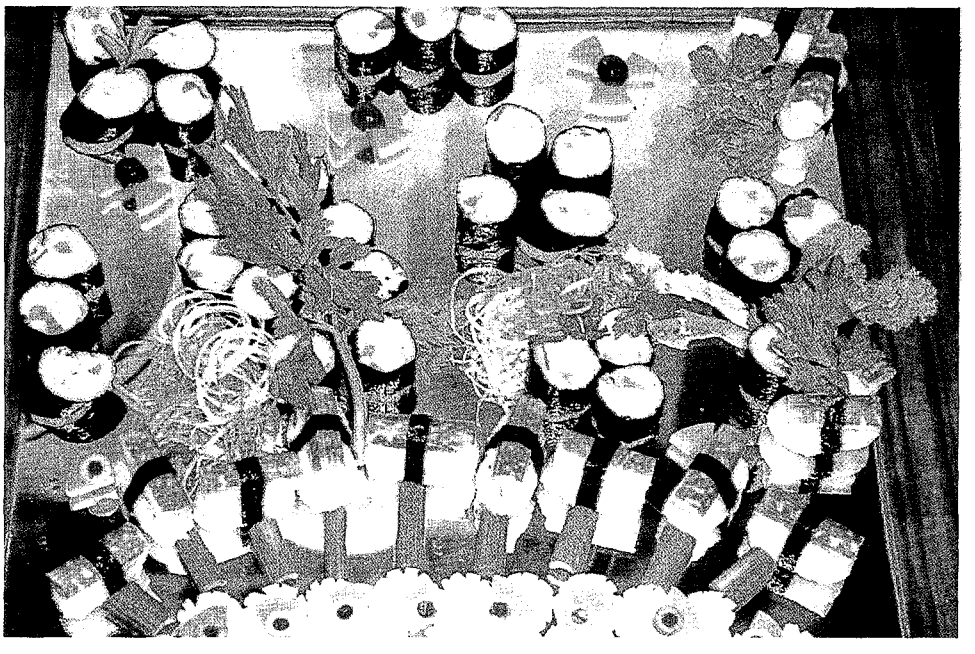
During the last 3 years many Seminar and workshops on Surimi and Crab-analog production have been held for the private sector, bankers, Chambers of Commerce groups, universities (8). According to Information marketing digest number 5/86 mentioned that the high demand of surimi based crab-analog will be increased in U.S.A. from 30,899 tons to 48,500 tons in 1985-1986 and 63,050 tons in 1987.

In Thailand surimi production was increased from 3,000 tons (1985) to 38,000 tons (1990). Four crab-analog factories have been established (Department of Fishery, A&N Food Co., Ltd.) in 1988, and B.S. Manufactories, Apitoon Enterprise Co., Ltd. in 1990. Production quantity has increased from 4,000 tons to 12,000 tons a year amounting to 800-1,000 million baht (about 40 million US $). About 85-95 percent of crab-analog is exported and 5-15% is for domestic consumption.

Recommendation :

Surimi, as a raw material for crab-analog processing, must be produced from good (fresh) quality fish or it is impossible to maintain high quality crab-analog. Washing is an important factor affecting the quality of raw surimi.

Low quality ingredients need to be eliminated to eliminate spoilage and degradation.



Several types of food made from cooked Surimi and Crab–analog

Consumers acceptability trials

1. Sub-Project Title : **Accelerated Technology Transfer on Macadamia as the New Industrial Crop (015)**

2. Responsible Agency : Highland Agriculture Office, Horticulture Research Institute, Department of Agriculture

3. Life of Project : 1987-1990

4. Implementation Sites :

4.1 Chiang Rai Hort. Res. Centre	
4.2 Wawi Highland Agr. Res. Sta.	Chiang Rai Province
4.3 Fang Hort. Exp. Sta.	Chiang Mai Province
4.4 Khun Wang Royal Highland Agr. Res. Sta.	Chiang Mai Province
4.5 Mae Chon Luang Highland Agr. Res. Sta.	Chiang Mai Province
4.6 Pong Dang Royal Development Centre	Mae Hong Sorn Province
4.7 Huey Hong Krai Development Centre	Chiang Mai Province
4.8 Khao Khor Highland Agr. Res. Sta.	Petchaboon Province
4.9 Phu Ruer Highland Agr. Res. Sta.	Loei Province
4.10 Doi Mu Ser Hort. Exp. Sta.	Tak Province
4.11 Cha Choeng Sao Rubber Res. Centre	
4.12 Thung - Pel Rub. Exp. Sta.	Chantaburi Province
4.13 Sri Saket Hort. Res. Centre	
4.14 Phu-Pan Royal Development Centre	Sakonakorn Province
4.15 Pak Chan Land Settlement	Ranong Province
4.16 Trang Hort. Exp. Sta.	Trang Province

5. Approved Budget :

Loan	US $	295,484	
Grant	US $	75,744	
Total	**US $**	**371,228**	

6. Actual Expenditures :

Loan	US $	228,104	
Grant	US $	56,163	
Total	**US $**	**284,267**	**or approximately 84% of approved budget**

7. Summary of Background and Objectives :

Macadamia is one of the most delicious and expensive nuts. The demand is strong and the production is insufficient, even though there are several producing countries such as the U.S. (biggest producer), Australia, Mexico, Costa Rica, South Africa and Kenya. As far as climatic conditions, it is expected that macadamia will be another cash crop adapted well to Thailand conditions. This project is aimed at speeding up commercial planting of macadamia as a new industrial crop; the technology can be transferred easily to farmers and the private sector.

8. Accomplishment :

A. 10 commercial cultivars of macadamia mainly from Hawaii. and Australia as follows : 246,333,344,508,660,741,800. from Hawaii and OC (Own Choice) H2 (Hinde) and HY (Rankine) from Australia were introduced for testing in various parts of the country. Most of the 16 sites were located in the North, since the U.S. expert felt that this part of the country would be the most suitable for macadamia. The rest were planted in the Northeast, Southeast, and the South.

B. From results at these 16 experimental sites, it can be concluded that :

1. The minimum and maximum temperature ranges suitable for macadamia is 12°-35°C.

2. The optimum rainfall is 1,500 mm. or 60 inches or more. If macadamia is planted in an area that has a lower rainfall average, free growth will be retarded unless irrigation, mulching, and wind break are provided.

3. Heat stress is common in the lowlands and some cultivars can not tolerate heat but grow well in the cooler highland area, i.e. cultivar 508 from Hawaii.

4. Macadamia grows best in well-drained soils and also in area that have good wind breaks.

5. The tree is optimum range of low temperature is 18°C for a period of nearly a month to induce flowering.

6. Macadamia should grow better in an area located above the lattitude 16° N or the upper Northern region, with some exceptions. The tree is grown in an other regions, it should be planted at higher altitudes of at least 500 meters above sea level.

7. Macadamia can grow well in high altitudes up to 1,600 meters with the exceptionally good quality of both kernel, and shell thickness. This finding is contrary to the information in various old texts.

8. Most of the introduced cultivars (except HY and 333) have adapted well to Thai condition and can produce good nuts of international quality, not only percent of grade 1 kernel recovery and oil content but also the total production.

9. Macadamia starts to bear nuts in 4 - 5 years girth, annual production, rainfall, temperature, nut · quality should be measured for another 5 - 6 years for solid conclusions and confirmation of early results.

10. Even though the yield of each cultivar was not well recorded, it can be said that the following cultivars: H2,344,660,741, and OC should be recommended to the public.

C. There are two main area for cultivar multiplication, 200 rai at Wawi Highland Agricultural Research Station and 215 rai at Phu Ruer Highland Agricultural Research Station.

D. New introductions of another 29 cultivars and regional tests were located at Mae Hae Highland Agricultural Headquarter and Mae Chon Luang Highland Agricultural Research Station.

E. Macadamia has been successfully introduced in a new area development project at Doi Tung in the area of more than 2000 rai.

Grafted Macadamia trees showing very good growth for 2 year old trees.
Chiang Rai Horticultural Research Center

Kernels of Macadamia Nut # 246

1. Sub-Project Title : **Wheat Technology Transfer for Local Utilization (016)**

2. Responsible Agency :
2.1 Department of Agriculture
2.2 Department of Agricultural Extension
2.3 Chiangmai University
2.4 Kasetsart University
2.5 Huai Si-Thon Pilot Project
2.6 Agricultural Research and Training Center, Lampang

3. Life of Project : 1987-1989 DOA, DOAE and HST was extended for 1 year to 1990

4. Implementation Site : Chiangmai, Chiangrai, Maehongsorn, Lampoon, Lampang, Phayao, Phrae, Nan, Kalasin, Mukdahan, Nakorn-Panom and Ubolrachatanee

5. Approved Budget and Actual Expenditures (Loan) :

	Approved Budget	Actual Expenditure	(US $)
DOAE	85,477	54,498	
DOA	66,785	58,196	
CMU	51,424	39,175	
KU	8,410	8,123	
HST	55,250	51,117	
Total	**293,638**	**236,647**	**or approximately 81% of approved budget**

6. Summary of Problems and Objectives :

A. Problem :

Wheat is a cereal crop that plays an important role in Thailand. Each year we import the grain and its products costing more than 1 billion baht. If farmer in rural could produce wheat as a second crop, it would improve their nutrition and increase their income. There are some sites in Northern Thailand where wheat can be grown economically.

B. Objectives :

1. To transfer known technology on wheat cultivation and utilization to farmers, particularly those who live in the upper north and some areas in the northeast.
2. To promote local utilization of wheat which will improve nutrition and increase income.

7. Accomplishments :

7.1 Demonstration plots of wheat cultivation were established on 920 rai by DOA,DOAE,CU and ARTC in the upper north and KU,HST in the northeast; average yield was 143 kg/rai. During the secend phase in 1990 the average yield was 183 kg/rai.

7.2 Training programs on wheat cultivation for researchers, district agricultural extension workers and farmers were organized; 2,000 farmers attended the training courses.

7.3 Demonstrations of local utilization of wheat were arranged by DOAE, ARTC, KU and HST; 4,170 persons attended.

8. Benefits and Recommendations :

A. Benefits :

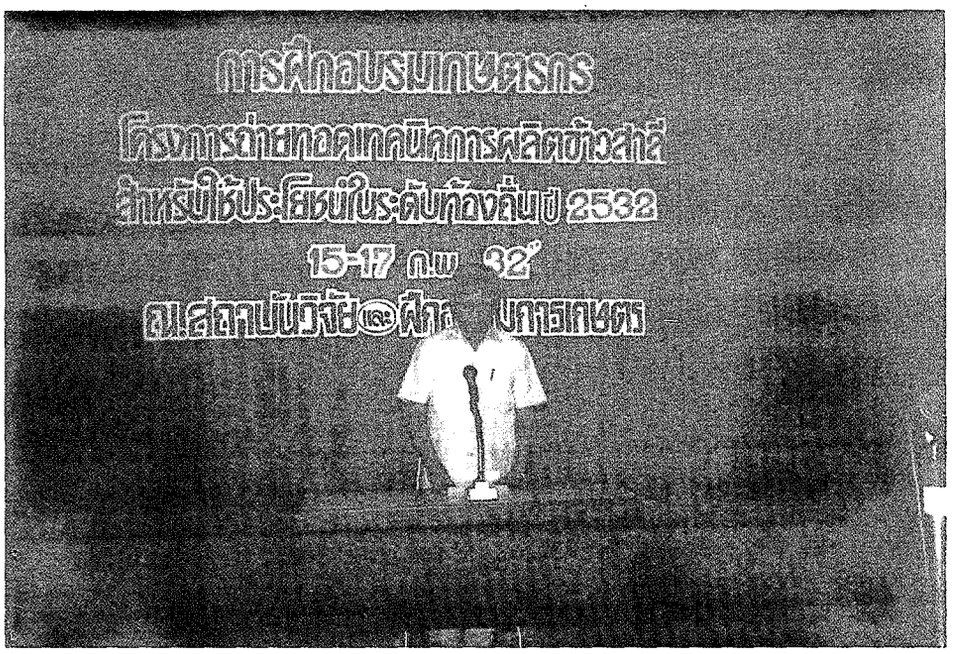
1. Farmers gained knowledge of wheat cultivation techniques and home utilization of wheat products.

2. Wheat can now be grown by farmers. Income can be increaded by 500-1,000 baht/rai/year. Housewives and small local industrial plants can gain more income by making products from locally grown wheat. Wheat growing farmers can consume food high in nutritive values.

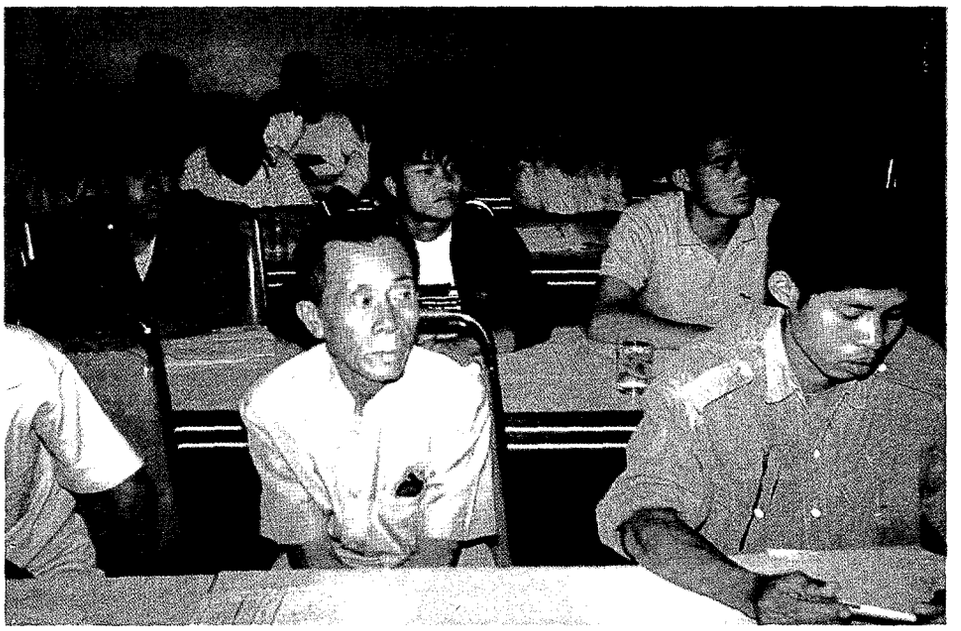
B. Recommendations :

1. Cultivation aspects : Potential wheat growing areas should be indentified. Cultivation technology should be developed for each area that differs in environmental conditions. Crop cultivars adapted to various conditions could produce higher yields.

2. Wheat products should be developed for many uses including industry. More training and demonstration for housewives and local bakers should be organized.



Training for farmers on techniques of wheat production

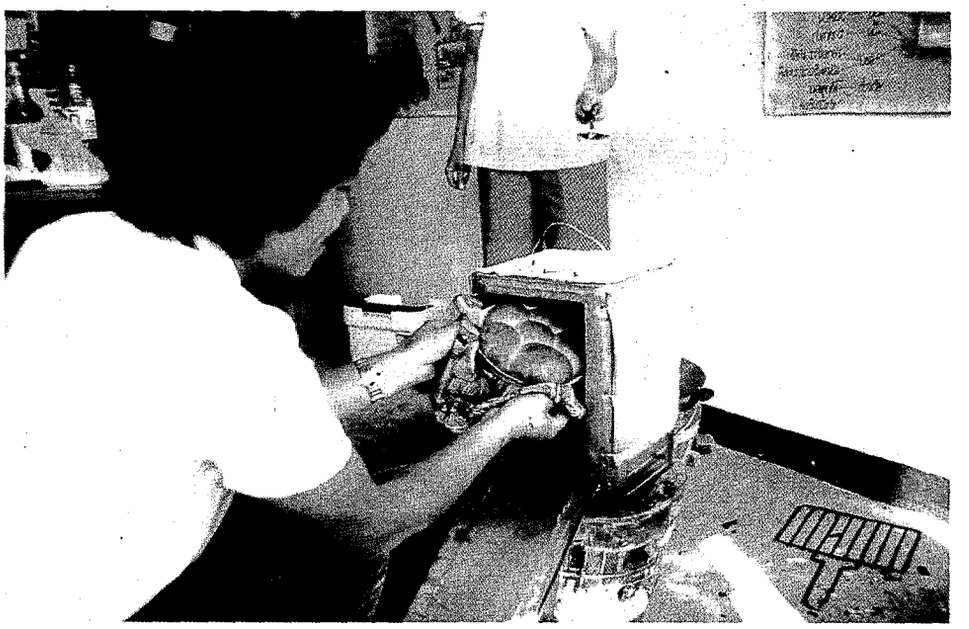


Farmers attending the wheat training

Farmers visit wheat field

Demonstration of wheat cultivation

Farmer's wheat field under upland rainfed
conditions in Fang District, Chiangmai.
The size of farm is 3 rai the yield was 352 kgs/rai



Baking bread made of wheat flour in tin-can-oven by farm housewives.

Training on utilization of wheat products for housewives and field extension workers

Training on utilization of wheat products for students, teachers and local bakers in Lampang Province.

1. Sub-Project Title : **The Application of Maize Mobile Dryers (018)**

2. Responsible Agency : Agricultural Development Administrative Division, Department of Agricultural Extension, MOAC.

3. Life of Project : Oct. 1986 - May 31, 1989.

4. Implementation Site : Pechaboon Agricultural Co-operative, Pechaboon Province. Chumrus Pongsalee Silo, Payuhakiri District, Nakornsawan Province.

5. Approved Budget :

Loan	US $	144,362	
Grant	US $	24,000	
Total	**US $**	**168,362**	

6. Actual Expenditure

Loan	US $	140,027	
Grant	US $	22,070	
Total	**US $**	**162,097**	**or approximately 96% of approved budget**

7. Summary of Problem and Objectives :

A. Problem :

The bulk of Thai maize is harvested during the monsoon season, August to September. Because of the rain and high humidity the maize is highly susceptible to the aspergillus fungi, a saprophyte, when the individual kernels are damaged during shelling at up to 25° moisture content. The fungi then can penetrate the maize and the toxin, aflatoxin, is readily formed. If the maize is dried to below 15° moisture content before shelling in the field and below 13° at the export silos, the opportunity for aflatoxin in form is negligible. Aflatoxin is harmful to man and beast. The maxzimum safe aflatoxin content for humans is 20 PPB and for animals ranges from 50-100 PPB.

B. Objectives :

- To improve the quality of Thai maize to meet the requirement of export and local markets.
- To reduce aflatoxin in maize.
- To transfer the technology of maize drying to farmers, middlemen, Agricultural Co-operative officers and DOAE officers.
- To demonstrate the application of maize mobile dryer to farmers, middlemen and interested people.

8. Accomplishments :

The 3 mobile dryers, 1 diesel type and 2 LPG type, were demonstrated at Pechaboon Agricultural Co-operative Group between October and December 1987 and between August and December 1988. The total capacity of 3 dryers is about 31 tons per batch demoisture for 3-4% per hrs. Therefore it is 3 hrs. to demoisture maize from 21-24% to 14-15%.

From the demonstrated maize mobile dryers at Pechaboon Agricultural Co-operative Group. There was a net profit of about 240 baht per ton over the traditional sale at 21% MC and the dried maize can be stored longer.

9. Benefits and recommendations :

A. Benefits :

1. Reduced the aflatoxin level in maize by drying the grain below the danger levels for aflatoxin infection.

2. Reduced the farmers disadvantage of having to sell maize at high moisture content.
3. Dried maize can be stored waiting for higher prices.
4. Non-aflatoxin maize sells for a higher price.
5. Reduced the cost for shipping water in the high moisture maize.

B. Recommendation :

If investment is made for drying maize only, it might not be profitable because the operating period is only 3 months/year so it is recommended to apply mobile dryers to other crops, such as soybean, rice, mungbean, etc. Thus, the operating period per year will be greater and provide a higher return of investment. About 1,700 farmers in the project has accepted the idea of using mobile dryer with their limited fund, long term loan is needed for investment. The private sector has accepted dryers too. Also, the value of Thai corn in the international market is no longer discounted 8 to 10 dollars per ton.

1. Sub-Project Title : **The Promotion of Copra Production Development project. (019)**

2. Responsible Agency : Crop Promotion Division, Department of Agricultural Extension

3. Life of Sub-Project : 1987-1989

4. Implementation Sites : Prachuabkirikan, Chumporn, Surathani, Nakornsithummarat, Chainat and Cholburi

5. Approved Budget :

Loan	US $	8,240
Grant	US $	6,601
Total	**US $**	**14,841**

6. Acutual Expenditures :

Loan	US $	2,774
Grant	US $	6,601
Total	**US $**	**9,375**

or approximately 63% of approved budget.

7. Objectives :

7.1 To develop copra production technology for Extension Agent.
7.2 To transfer copra production technologies to the farmers.
7.3 To upgrade copra quality (aflatoxin) and increase farmer's income.

8. Accomplishments :

8.1 Ten extension agents were sent to the Phillipines for 7 days a study tour on copra production and development in 1988.

8.2 Five copra dryers were constructed and sent to Prachuabkirikan, Chumporn, Surathani, Nakornsithummarat and Cholburi for each unit.

8.3 Fifty Extension Agents and 1,283 Coconut farmers from five provinces were trained in copra production technology. (DOAE cooperated with Southern Regional Agricultural Extension Office and Chainat Mechanical Promotion Center.

9. Benefits of the project :

9.1 Copra production using the new dryer is free from alflatoxin.
9.2 Copra quality has been improved by drying and the farmers receive higher incomes.
9.3 The new dryer has promoted the coconut oil industry as well.

1. Sub-Project Title : **Arabica Coffee Development in Northern Thailand (020)**

2. Responsible Agency :

2.1 Department of Agriculture
2.2 Department of Agricultural Extension
2.3 Royal Forestry Department
2.4 Northern Regional Agricultural Center

3. Life of Sub-project : 1988-1989

4. Implementation Sites : Tak Province, Petchaboon, Chiangrai, Chiangmai and Maehongsorn

5. Approved Budget :

Loan	US $	406,932	
Grant	US $	17,258	
Total	**US $**	**424,190**	

6. Actual Expenditures :

Loan	US $	231,976	
Grant	US $	16,146	
Total	**US $**	**248,122**	**or approximately 58% of approved budget**

7. Summary of Problems and Objectives :

7.1 Problems :

The important problem of Arabica coffee growing in the north is that the variety grown is susceptible to leaf disease. This disease destroys coffee plants resulting in lower yields. To solve this problem, the Department of Agriculture has selected and propagated coffee seedlings that are resistant to leaf rust disease. Farmers are receiving this resistant variety through the Departments concerned to be grown in the field.

7.2 Objectives :

1. To develop and transfer know how technology on Arabica Coffee planting and producing to farmers.
2. To increase Arabica Coffee production for domestic use.
3. To conserve forest resources by extension Arabica Coffee plantation to farmers and hilltribes in agroforestry systems.

8. Accomplishments :

8.1 2,000,000 leaf rust resistant coffee seedlings were produced and planted.

8.2 Arabica coffee extension plots, 1,000 rai from 5 provinces, were arranged by DOAE to increase coffee products.

8.3 Training farmers and hilltribes on Arabica Coffee plantations in 5 provinces arranged by the departments concerned; 830 person attended.

9. Benefits :

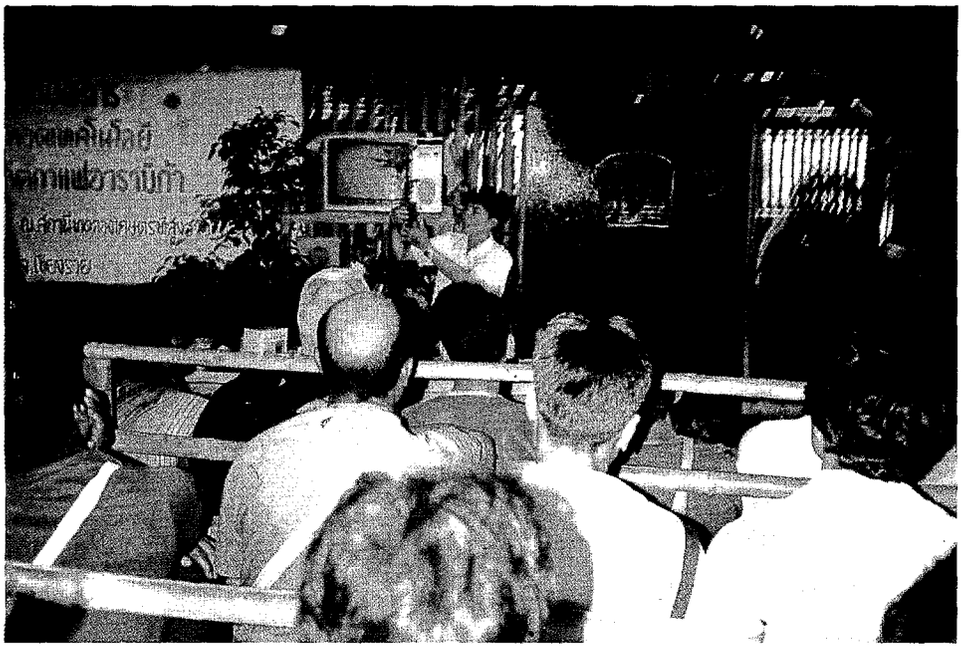
Arabica coffee growing area was increased by 5,000 rai. Coffee production will be increased about 1,200 metric tons in 1991.

10. Recommendations :

1. After the project has ended, it is appropriate to extend arabica coffee plantations using Royal Thai Government budget.

2. For Arabica coffee plantations to yield the most benefits, it is appropriate to study "Land use and soil capability" following "Zoning Area of Arabica Coffee Plantations in Northern Region"

Because the number of seedling from this project is still not enough for the farmers' demand coffee production is limited and insufficient to meet domestic demand for Arabica coffee. Thus, the government should continue supporting this project by increasing the multiplication of resistant cultivars.



Farmers Training on Arabica Coffee Plantations

Demonstate how to manage arabica coffee plot.

1. Sub-Project Title : **Control of Passionfruit Woodiness Virus by Cross Protection and Resistant Varieties. (021)**

2. Responsible Agency : Plant Virology Section, Division of Plant Pathology & Microbiology Department of Agriculture

3. Life of Project : 1988-1989

4. Approved Budget :

Loan	US $	53,381	
Grant	US $	24,655	
Total	**US $**	**78,036**	

5. Actual Expenditures :

Loan	US $	31,417	
Grant	US $	13,834	
Total	**US $**	**45,251**	**or approximatly 57% of approved budget**

6. Summary of Problem and Objective :

A. Problem :

Passionfruit is a new industrial crop which many farmers would like to grow because it is easily propagated and cultivated and the fruit has a good market both incountry and for export. The growing area are being expanded very quickly, but farmers face the big problem of virus diseases. The important virus disease fo passionfruit is passionfruit woodiness virus (PWV). The disease can be transmitted mechanically and by grafting. ***Aphis craccivora, A. glycines, A. gossypii*** and ***Myzus persicae*** are the vectors of the disease. Besides passionfruit woodiness virus, another virus that attacks passionfruit is cucumber mosaic virus (CMV). It also is transmitted mechanically by grafting and by aphids. Mixed infections of the two viruses on the same plant cause serious yield losses averaging 50 percent.

Because there are no known control methods for virus diseases and there are no chemicals to halt the disease, the best method to control virus diseases of passionfruit at present is by cross-protection. In this study we selected four mild strains of passionfruit woodiness virus under natural conditions. The research conducted in a greenhouse was to select the mild strains and to challenge the severe strain. We were successful in protecting against the severe strain under greenhouse conditions. Continuing studies are being carried out to confirm early results in the field. Cross protection to control virus diseases in very economical and widely successful in many crops.

B. Objectives :

To select several mild strains of passionfruit woodiness virus under natural condition and use the mild strains for control of the severe strain of the virus disease by cross-protection.

7. Accomplishments :

A. Studies of infected passionfruit under greenhouse and field conditions :

– A survey of passionfruit woodiness virus disease in many plantations including Chaingmai, Maehongson, Phetchaburi, Chainat, Prachinburi, Khon Kaen, Rayong and Chanthaburi showed 20-100% of disease infection.

– To determine the different strains of passionfruit woodiness virus, the infected leaves with different ranges of mosaic symptoms from mild to severe were collected and tested by ELISA against PWV antiserum. The leaves with mild mosaic symptoms which gave positive ELISA reactions were selected as mild strain inoculum sources. Four mild strains, selected from the survey under field conditions were MFR-1 (mild strian from Rayong No.1) MFR-2, MFR-3 and MFR-4.

Each mild strian was inoculated on healthy passionfruit seedlings to study the pathogenicity before being inoculated again on the same plant with the severe strain; to test the efficiency of cross protection after 1, 2, 3 and 4 weeks. The number of infections of passionfruit seedlings caused by mild strains were about 83%, 93%, 80%, 86% of MFR-1, MFR-2, MFR-3 and MFR-4, respectively. The test also indicated that mild strains provided the best protection against the severe strain 2-3 weeks after inoculation.

– Mild strain cross protection was also applied under both conditions. The experiment gave 66% and 59% successful disease control in greenhouse and field conditions, respectively.

– To increase the number of immune passionfruit plants, the pre-immunity plants from previous experiments were propagated by root cuttings in organic fertilizer. Within 2 weeks, 73% of the passionfruit cuttings products vigorous roots and were well established in the soil. The presence of PWV mild strains on each cutting, which could immunize the plant against the severe strain, was confirmed by ELISA test.

– Yield loss in passionfruit caused by PWV was also studied. Yield comparison among healthy and mildly infected plants: mild strains were challenged with the severe strain, and also severely infected plants were tested. The results under greenhouse conditions showed that the highest yield was on plants inoculated with the mild strains followed by the severe strain. The test also indicated that PWV decreased the amount of juice and the number of fruits on each infected plant which led to a large total yield loss. However, under field condition there were no differences in yield among 4 treated groups, as insect control was unsuccessful and masked the inoculations.

B. Laboratory studies :

– The virus injected plants were brought from the field and greenhouse to be checked by the ELISA test for passionfruit woodiness virus-Thai isolate antiserum. All samples tested showed a positive reaction.

– Studies on the causal agents of virus diseases on passionfruit plants showed that there were 2 different types of particles, one is the long-flexuous rod about 700-750 nanometers long that belongs to the polyvirus group. The other is isometric, the diameter of particles is about 30 nanometers and is in the cucumovirus group. In addition to the ELISA test, the diseased samples were checked by immunoelectron microscope (IEM) with PWV-Th and CMV antiserum. Results confirmed those found in the ELISA tests.

– Studies on host range and insect vectors of PWV. The host plants of PWV are in the families Amaranthaceae, Chenopodiaceae, Leguminosae, Passifloraceae and Solanaceae, Four species of aphids that transmit PWV are ***Aphis craccivora, A. glycones, A. gossypii*** and ***Mvzus persicae.***

– Studies on isolation of mixed infection of PWV-Th and CMV by inoculating the infected leaves of ***Chenopodium amaranticolor,*** then isolating the single local lesion on passionfruit seedlings; the infected plants showed PWV symptoms were checked by the ELISA test for PWV.

– Purification of PWV

The virus was purified from inoculated leaves of ***Micotiana bentamiana*** which already had been inoculated with PWV-Th isolate for 20 days by the following method: Blend frozen infected leaves in phosphate buffer containing Na_2SO_3 and EDTA; add chloroform and carbontetrachloride; squeeze through cheesecloth; add polyethylene glycol; centrifuge at low and high speeds; add Cs_2SO_4 and high speed ultracentrifugation for 18 hours. Yield are high with particles of flexuous rods about 700-750 nanometers by electronmicroscope.

C. Workshop and training :

A Workshop was conducted on "Control of passionfruit woodiness virus by cross protection" during 16-17 January, 1989 at the Northern Regional Office of Agriculture, Chiangmai; 50 participants from government, factories, businessmen and interested scientists attended. In this workshop, we transfered the knowledge of passionfruit viruses and how to control them. Dr. Dennis Gonsalves of Cornell University participated in the workshop.

8. Benefits and Recommendations :

A. Benefits :

1. The main infested areas and the widely spread areas of virus diseases in Thailand were determined. The important passionfruit growing areas are Chiangmai, Chiangrai, Maehongson, Phetchabun, Sukhothai, Chainat, Prachinburi, Rayong, Chanthaburi, Khon Kaen, Sakonakon and Loei provinces. The infectiousness of PWV varies from 20-100% in all locations.

2. Hosts of passionfruit woodiness virus are globe amaranth, ***Chenopodium amaranticolor,*** soybean, kintoki bean, top crop bean, yard long bean, ***Passiflora edulis, P. foetida,*** and tabacco.

3. Vectors of passionfruit woodiness virus are ***Aphis gossypii, A craccivora, A, glycines,*** and ***Myzus persicae.***

4. Causal agents of virus diseases on passionfruit are passionfruit woodiness virus and cucumber mosaic virus.

5. Four mild strains: MFR-1, MFR-2, MFR-3 and MFR-4 were selected to protect severe strains.

6. Efficiency of mild strains which can protect against the severe strain in greenhouse and field conditions were determined.

7. Propagations of pre-immune mild strains of passionfruit by root cuttings were completed.

8. Yield loss (Juice) related to passionfruit woodiness virus is about 50% on the average.

9. Purification and production of serum of passionfruit woodiness virus is useful for rapid tests of PWV in the field.

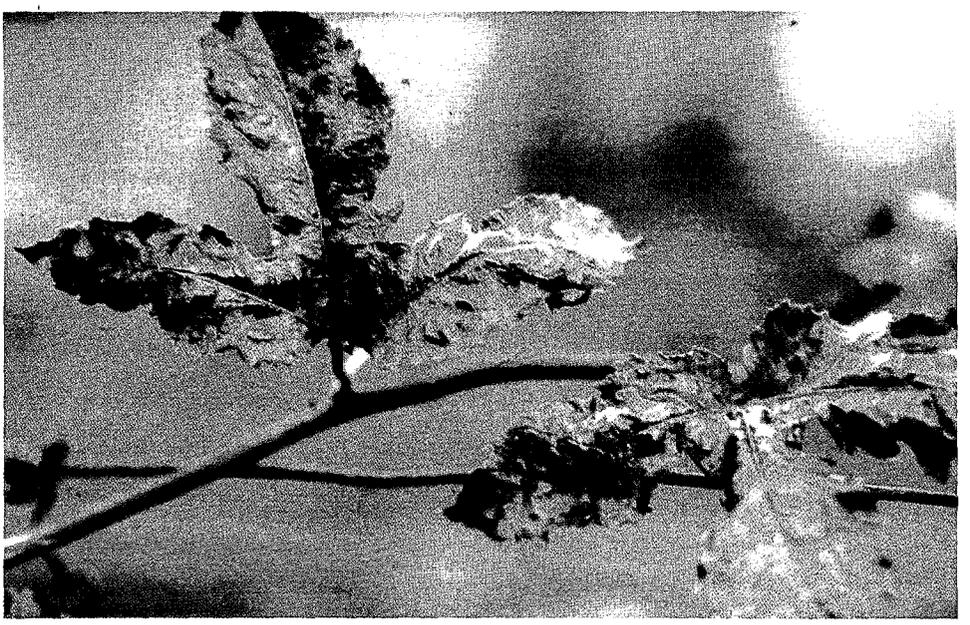
10. Knowledge on virus diseases of passionfruit and new technology were transferred to Thai and exchanged with International scientists by papers and poster sessions presented at International Pathology meetings. (Japan).

11. Provided advice to DOAE on the latest technology to take care of passionfruit and how to control virus diseases on passionfruit to the use of farmers.

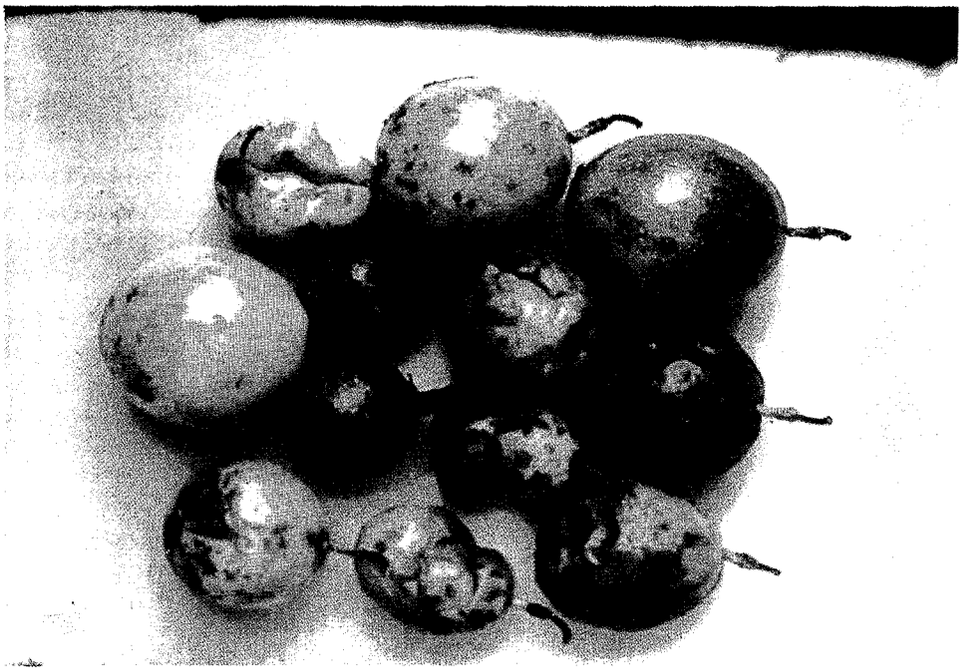
12. Introduced preferred varieties of passionfruit to farmers which will provied higher yields of fresh fruits and juice both for in country use and export.

B. Recommendations :

1. When the disease spreads to new areas the infected plants should be rogued out.
2. Eliminate weeds and hosts of virus diseases in passionfruit plantations.
3. Control the vectors of virus diseases.
4. Select the good healthy passionfruit plants for propagation and select the best fruits for seedlings.
5. Clean (sterilise) all utensils before and after working in the field.
6. When farmers become aware that the diseases are spreading, they should contact the government officers for help in controlling the diseases.



Infected leaves showing yellow mottling rugosity and puckering.



Fruits showing light and dark green areas, sometimes showing ring symptoms ; note that the size of the fruit are smaller than normal.

Comparative growth rates of passionfruit, 1. healthy, 2. mild strain, 3. severe strain and 4. mild + severe strain.

1. Sub-Project Title : **Artemia Culture and Processing Technology Transfer (024)**

2. Responsible Agency : Phetchaburi Coastal Aquaculture Station, Coastal Aquaculture Division, Department of Fisheries.

3. Life of Project : 1988-1990

4. Implementation Sites :
(1) Phetchaburi Coastal Aquaculture Station
(2) Samuthsakorn Coastal Aquaculture Development Center
(3) Salt Pan Area in Prachuabkirikhan, Phetchaburi, Samutsongkram, Samutsakorn, Chachoengsao, Chonburi, Rayong and Chanthaburi Province

5. Approved Budget :

Loan	US $	291,897
Grant	US $	125,000
Total	**US $**	**416,897**

6. Actual Expenditures :

Loan	US $	271,392	
Grant	US $	7,438	
Total	**US $**	**278,830**	**or approximately 70% of approved budget.**

7. Summary of Problems and Objectives :

A. Problem :

Artemia or Brine shrimp is one of the marine aquatic species in the same class as shrimp, lobster or crab but it does not have exoskeleton (carapace). ***Artemia*** is well suited to be used for nursery and rearing both marine and freshwater shrimp species such as tiger prawn ***Penaeus monodon,*** white shrimp ***P.mergeinsis,*** giant freshwater prawn ***Macrobrachium rosenbergii,*** as well as sea bass ***Lates calcarifer,*** grouper ***Epinephelus sp.*** or ornamental fishes. ***Artemia*** not only has good feed properties i.e. high in nutritive value, small in size, and no exoskeleton but also artemia can be collected and preserved for a long time as cysts. When one wants to use ***Artemia*** cysts they are immersed in seawater with aeration; the cysts will hatch in a few hours and are ready to be used as feed.

Artemia are naturally collected from salt lake or ponds that have a high salinity content. Artemia is not native to Thailand, all of its come from the USA originally. The Department of Fisheries has been successful in culturing ***Artemia*** in salt ponds since 1979 and has transfered the knowledge to the salt farmers to practice but the early results were not good because it was necessary to develop and improve techniques.

In 1986, Thailand had 300 shrimp and/or Fish hatcheries that used ***Artemia*** for feed. The use exceeded 100 tons/years so that more than 95% of artemia was imported; in 1989 was 400 tons/ valued at 700 million bath. The demand for ***Artemia*** cysts was rapidly increasing every year following the expanding area of fish/shrimp farms. Prices have increased and the quality has not been maintained. At certain periods ***Artemia*** cysts had not been available for use in aquaculture. Department of Fisheries recognizing that the shortage of ***Artemia*** cysts supply would affect fish-shrimp production, so the DOF enlisted the support of the more than 50,000 rai of salt farms that could be integrated for ***Artemia*** production. Therefore, the Department of Fisheries have implemented this project to increase ***Artemia*** culture and its processing.

B. Objectives :

1. Develop and transfer technology for high yield production of ***Artemia*** cysts and biomass that have been used in the USA for use in Thailand.

2. Intensify research on ***Artemia*** strains to determine the best strain that suitable for local condition.

3. Develop and transfer technology of preservation and processing of ***Artemia*** cysts and biomass that have been used in the USA for application in Thailand.

4. Demonstrate, extend and train trainer in ***Artemia*** culture and processing to be passed to the farmers.

8. Accomplishments/Recommendations :

8.1 Preparation of the facilities and equipments

Artemia pond renovation to demonstrate the technique of ***Artemia*** culture, land preparation, how to set up the fiberglass tanks for experiments on different strains of ***Artemia,*** drainage systems, aeration systems and electricity supply systems have been completed.

8.2 Development of high yield Artemia culture techniques

Dr. Robert Rofen, Hayward, Cal, expert on Artemia culture technique had come to visit the project and has some recommendation as follow;

8.2.1 ***Artemia*** strains from San Francisco Bay that have been used in Thailand were good strains; they should be re-introduced using the San Francisco Bay strain every 3 years.

8.2.2 ***Artemia*** ponds must be dug deeper to at least 1.5 meters for ***Artemia*** biomass production. The ***Artemia*** ponds should be constructed with overflow pipes or other types of drains at the surface water that will eliminate fresh rainwater. Floating bamboo poles should be used to prevent ***Artemia*** cysts from being driven onshore by wind and wave action. Offshore bamboo barriers should be considered at the corners of ponds for more efficiency on cyst harvesting.

8.2.3 The use of ***Artemia*** biomass as shrimp feed should give best results and is possible to do, but must wait until the price of ***Artemia*** biomass decreases.

8.2.4 The study tour program for Thai project staff that Dr. Rofen set up was good; the staff will see both laboratory and field work on an industrial scale in USA & Canada. (Cancelled by USAID following coup) The staff of the project has been continuously culturing for high yield ***Artemia*** production.

8.3 Research on Artemia strains

Dr. Robert Rofen has brought the San Francisco Bay strain to the project, and the project staff has received an other 5 strains from Belgium. Presently the project staff are screening to determine which strains have the highest yield potential under local condition to transfer to the farmers in the future.

8.4 Adopting US. preservation and processing technique

For this activity, no expert will be coming for transfer of technology. However, the project staff read the literature and made personal contact with the technicians at Kasetsart University. There are several types of ***Artemia*** processing such as ***Artemia*** freeze dry, ***Artemia*** flakes or ***Artemia*** meal and different methods for preservation of the products (deep freeze, vacuum tin pack or nitrogen seal pack).

8.5 Demonstration ponds

The demonstration ponds for high yields of ***Artemia*** production were located at 9 private farms; one in Chonburi, one in Chacheangsao, two in Samutsakorn, two in Samutsongkram and three in Phetchaburi province.

8.6 Training activities

Local training on Artemia Culture, Processing and their Application have been carried out two times at Phetchaburi Coastal Aquaculture Station. The farmers from 7 provinces such as Chonburi, Chachoengsao, Samutsakorn, Samutsongkram, Phetchaburi, Prachuabkirikhan and Nakornsritammarat 64 persons and 7 government officers have been participated.

9. Benifits

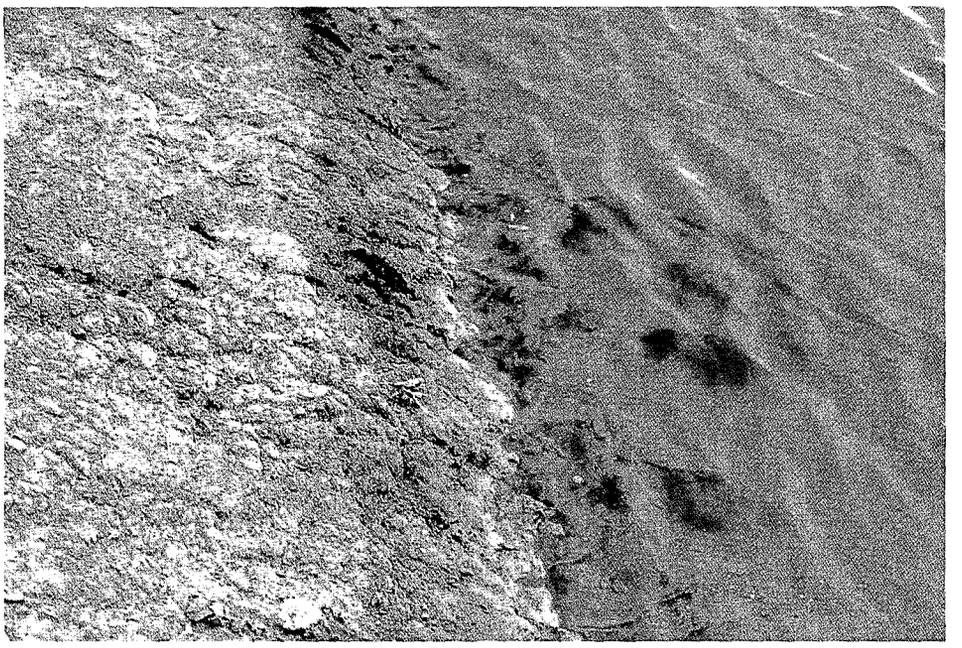
9.1 A well equipped training center with an ***Artemia*** demonstration pond, hatchery and laboratory, and equipment for processing ***Artemia*** products is in place.

9.2 ***Artemia*** demonstration ponds are located in 5 provinces for training farmers in each area.

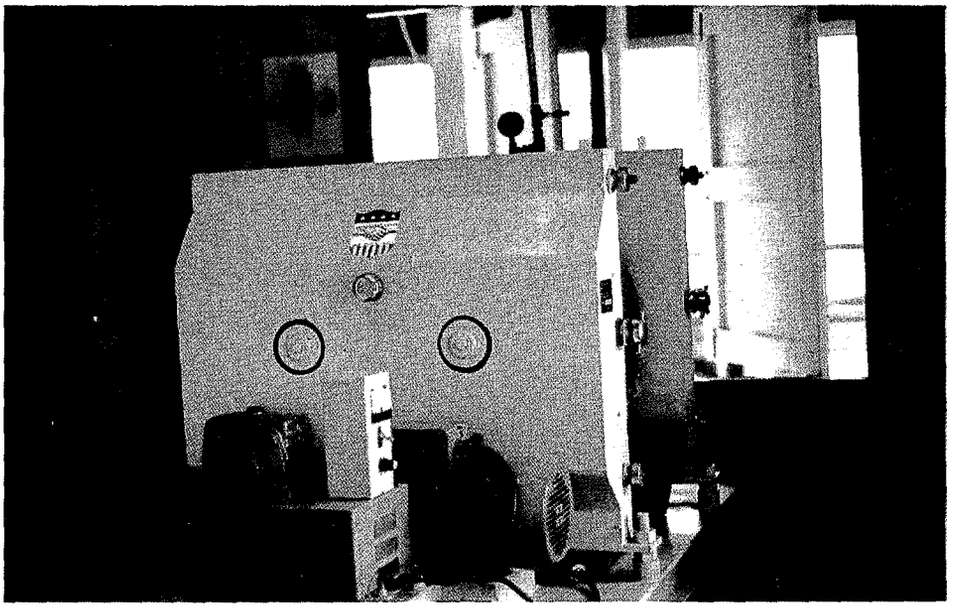
9.3 At least 64 farmers from 7 provinces have already been trained either on culture technique or processing technique.

10. Recommendation

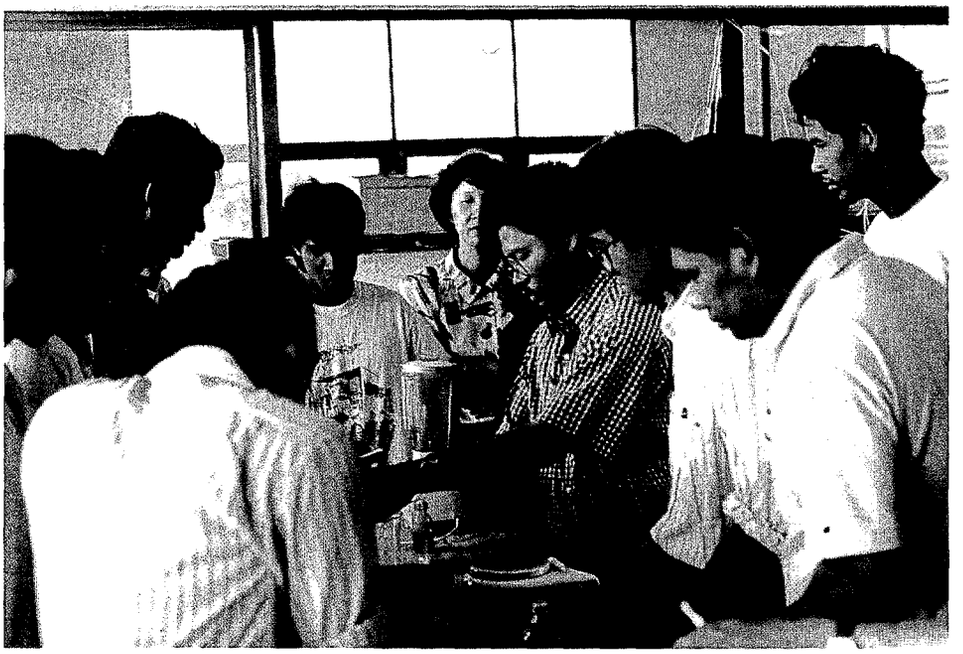
Presently, the techniques of ***Artemia*** culture and processing have been developed and applied quite successfully in Thailand. There is good potential for ***Artemia*** to develop into a large scale industry. The future work should emphasis intensively promotion to farmers.



Artemia biomass production in a pond at Phetchaburi Coastal Aquaculture Station



Drum Dryer used for producing *Artemia* Flake for shrimp biomass feed.



Processing

Culture – pond Construction

1. Sub-Project Title : **Hatchery and Culture Technology Transfer for *Penaeus Monodon* Fabricius Production (025)**

2. Responsible Agency : Phuket Coastal Aquaculture Development Center
Coastal Aquaculture Division, Department of Fisheries and
Faculty of Science, Chulalongkorn University

3. Life of Project : 1988-1990

4. Approved Budget :

Loan	US $	252,248	
Grant	US $	36,600	
Total	**US $**	**288,848**	

5. Actual Expenditures :

Loan	US $	214,169	
Grant	US $	9,566	
Total	**US $**	**223,735**	**or approximately 79% of approved budget**

6. Summary of Problems

P.monodon hatchery and culture in Thailand has increased rapidly; from 1976 to 1990 the number of hatcheries increased from 10 to more than 200 and the growing ponds increased from 76,500 rai to 500,000 rai. The demand for ***P.monodon*** larvae exceeds the supply and prices are high. There is also a shortage of ***P.monodon*** broodstock both cultured and captured.

In recent years the need to reduce cost of production and increase yields have had a major influence on the rapid introduction of modern technology to marine shrimp farming in Thailand. Quality feed is most important in assuring success in shrimp farming. Economic considerations require that feed cost, which is 50-60% of total production cost, be minimized. One approach that shrimp farmers can use to decrease their expenditures is to produce their own feed. This is possible through the use of appropriate technology and locally produced raw materials. The quality and nutritional value of the prepared feed must also be comparable to the diets commercially produced.

Food Technology and Marine Science departments, Chulalongkorn University are conducting research on production of marine shrimp feed by concentrating on production cost reduction, the introduction of appropriate technology, and feed quality improvement.

7. Objectives :

A. Department of Fisheries

1. Increase the production of ***P.monodon*** broodstock.
2. Improve spawning techniques in hatcheries and rearing technique of ***P.monodon*** broodstock for high quality larvae.
3. Transfer the hatchery and pond technology to the staff of Department of Fisheries and to shrimp farmers.

B. Chulalongkorn University

1. To transfer and develop appropriate technology for marine shrimp feed formulation and processing.
2. To reduce the cost of shrimp production through feed cost reduction.
3. To improve and assure the quality and nutritional value of commercially produced feeds.
4. To help solve some crucial problems facing the shrimp farming industry.

8. Accomplishment :

A. Department of Fisheries

Technology Transfer activities :

1. ***P.monodon*** rearing in ponds and net cages for broodstock. There are four basic systems to be extended :

1.1 ***P.monodon*** rearing in ponds from PL_1 broodstock; 10 crops were grown in 1988-1990. Rearing the shrimp in 1-3 rai ponds until 12-18 months old and then inducing spawning by eyestalk ablation.

1.2 ***P.monodon*** rearing in ponds from large juvenile to produce broodstock. About 1,000 juveniles (13 months old) from Surathani Coastal Aquaculture Development Center were transfered to Phuket Coastal Aquaculture Development Center for rearing into the broodstock in a 3 rai pond. Rearing this shrimp for 15-18 months and then inducing spawning by eyestalk ablation to produce broodstock.

1.3 ***P.monodon*** broodstock was cultured in ponds using the under size captured broodstock (70-80 g.). The objective of this activity was to use the under size captured broodstock ***P.monodon*** by feeding in ponds 1 month and then inducing spawning by eyestalk ablation.

1.4 ***P.monodon*** broodstock was cultured in net cage using under size captured broodstock (70-80 g.). This objective was the same as 1.3.

2. Induced spawning of ***P.monodon*** broodstock. Three basic systems were tested :

2.1 The broodstock from the farm ponds age 12-18 months were induced to spawn by eyestalk ablation.

2.2 The captured broodstock from the wild (70-100 g.) reared in cages and farm ponds and spawning induced by eyestalk ablation.

2.3 The broodstock is injected with hormone to induce spawning.

Results of the experiments; the broodstock from the ponds and cages can be used to the induced spawning by eyestalk ablation. The suitable age was over 16 months and suitable size (male were 24 cm. length and 110 g. weight and female were 25 cm. length and 130 g. weight) The fecundity was 165,000-235,000 eggs and hatching rate was 9-35%.

For the induced spawning by hormone injection; was not successful.

3. Improvement technique on nursing ***P.monodon*** in hatchery for high quality. There are three basic systems :

3.1 The nursing ***P.monodon*** on natural feed plus artificial feed gave the highest survival rate.

3.2 The survival rate of nursing ***P.monodon*** on antibiotics everyday until PL_1 gave the higher survival and growth than the other tests.

3.3 Growth and survival rates of ***P.monodon*** larvae nursing under controlled temperatures were higher than when the temperatures were uncontrolled.

4. Seminar and Training :

4.1 A seminar program on hatchery technology transfer for 10 junior biologists was held in Phuket Coastal Aquaculture Development Center June 6-7, 1990. The meeting consisted of seminar and plenary lectures by invited speakers specializing in shrimp culture ***P.monodon.***

4.2 A training program on the culture technology transfer for 15 fisheries officers held in Phuket Coastal Aquaculture Development Center June 18-21, 1990.

4.3 Five biologists from the Department of Fisheries made a study tour in USA on shrimp culture and hatchery techniques from 29 September to 16 October 1990.

B. Chulalongkorn University

Activity-1 **Effect of Storage Time and Temperature on Quality of Shrimp Feed Composition.**

Local commercial shrimp feeds from five companies were stored at 3-5°C and 27-30°C for 8 weeks. During storage, samples were analysed at 15 day-intervals for the quantities of protein, fat, moisture, ash, mineral and fiber.

The protein and fat levels of all samples decreased as storage time and temperature increased. Only slight changes were observed in the moisture level. The quantities of ash, calcium, phosphorus and fiber were not affected by either storage time or temperature.

Activity-2 **Effects of Commercial Feed Sources on Growth and Survival of Juvenile Prawn.**

A study using feeds from activity-1 was conducted on juvenile giant tiger prawn (P-6). The highest average growth rate was observed in animals fed a diet containing high protein and having a high water stability value. Survival rate was not affected by feed source.

Activity-3 **Production of Feed Pellets With Sea Algae Extract as the Binder.**

Alginate was extracted from ***Choospora minima.*** The extract was used as the binder in feed at 0.5, 1.0, 1.5 and 2.0% levels. The 1.5% level produced the highest water stability in the feed. The diet formulated with 1.0% Guar gum as the binder was compared with the commercially produced feed from C.P. Feed Co., Ltd.

The binding ability of alginate is better than that of Guar gum but pellets from both treatments were less stable than the commercial feed. Highest to lowest weight gain was observed in animals fed with C.P. feed, alginate containing feed and Guar gum fomulated feed, respectively. No significant difference in survival was seen between the groups fed with the alginate and with the commercial feeds. The lowest survival was observed in prawns fed with the Guar gum containing feed.

Activity-4 **Correction of Discoloration Problem in Giant Tiger Prawn.**

The shells of Giant tiger prawn fed local commercial feed (CF) developed a blue color instead of the natural grayish brown. Correction of this discoloration was attempted nutritionally by a comparative feeding study with three different diets; (1). the CF, (2). the standard normal feed fortified with 50 mg/kg astaxanthin, (AF) and (3). the standard normal feed fortified with 5% brown seaweed - ***Choospora minima*** (BF).

After four-week-feeding, animals fed with the AF developed fully grayish brown which is the natural color for giant tiger prawn. Analyses of the carotenoid levels showed that the groups fed with AF, EF and CF accumulated 32%, 57% and 14% extra carotenoids respectively. The brown seaweed increased the carotenoid but failed to overcome the blue discoloration, the CF fed animals developed a deep blue color. Most of the carotenoid detected was in the form of astaxanthin and the accumulation was higher in the shell than in the flesh.

Activity-5 **Various binders of Feed for Juvenile Giant Tiger Prawn.**

Effect of kind and quantity of eight binders on quality of prawn feed were studied. On the basis of binding ability and cost, the most appropriate samples are lignosulfonate at 1.0% and cross-linking tapioca starch at 2.5%.

A feeding study was carried out with five diets. The Na was the control inwhich 1% sodium alginate and 1.5% sodium hexametaphosphate were the binders. The other samples comprised the FF using 40% fresh trash fish as protein source and binder; the ISP using isolaied soy protein as protein source and binder; the LS, using 1% lignosulfonate as binder; and the MS, using 2.5% cross linking tapioca starch as binder. Feeding of juvenile prawn of about 5 g. initial body weight for seven weeks showed that the LS and MS provided the animals with the highest growth rate.

The efficiency of shrimp feed production by the pelleting method was compared with that of the simple meat grinding method. In a feeding trial of juvenile giant tiger prawn, growth rate was higher in animals fed with diet produced by the pelleting procedure. The cross-linking tapioca starch was more appropriate as a binder in the pelleting method.

Activity-6 **Production of Feed for Prawn Larvae**

Appropriate conditions for producting prawn larvae feed by microparticulation was studied. The best quality feed was used in a feeding trial on giant tiger prawn larvae.

The mixing of the feed ingredients at 30°C before heating at 85°C to dissolve the carragenan gum was selected as the most appropriate method. Samples were dehydrated by spray-drying and freeze-drying retained more vitamin C than those produced by cabinet dyring and vacuum drying.

A feeding study on giant tiger prawn larvae stage 3 to post larva 2 revealed that the freeze-dried and the vaccum dried feeds provided larvae comparable survival to the group fed with the natural feed and superior to those given the commercial feed. No significant differences in growth rates were observed among larvae fed six different diets. The processed feed can be kept at 4-10°C under N_2 atmosphere for 4 months. The production cost (materials + energy + packaging) was 450 baht per kg. while those commercially produced can be locally purchased at 2,500-3,500 baht per kg.

Activity-7 **Production of Feed for Juvenile Giant Tiger Prawn by Extrusion Cooking.**

The production of prawn feed by a laboratory extrusion cooker (Brabender # 823500 Laboratory Extruder 20 DN) was studied. A feeding study was carried out to compare the efficiency of extrusion cooking and pelleting (California Pelleting Machine) methods.

The use of a binding agent can be omitted in production of feed by extrusion cooking. The best condition found were : 2 mm. - diameter, 1 : 1 screw; 10 rpm. screw feeding speed; 36-37°C barrel temperature setting; 44% moisture content of feed mix; 60°C cabinet drying temperature for the extrudate and post - extrusion steam cooking to increase the water stability of the extrudate.

Results from feeding studies indicated that extrusion cooking and pelleting were comparable to other methods with respect to their efficiency in the prawn feed production.

9. Benefits and Recommendations :

A. Benefits

1. Techniques for the rearing of ***P.monodon*** in farm ponds and net cages to develop broodstock was transferred to farmers.
2. The techniques for induced spawning of ***P.monodon*** broodstock from farmer ponds and net cages was transferred to farmers.
3. Understanding of the nursing techniques for ***P.monodon*** larvae for high production was transferred to farmers.
4. Seminars and training on hatchery and culture technology for development of ***P.monodon*** was transferred to fisheries officers and shrimp farmers; this knowledge will be very useful in developing farm ponds.
5. The study tour participants observed ***P.monodon*** culture and hatchery and exchanged ideas with foreign researchers. Knowledge gained will be useful in developing the shrimp hatchery and culture techniques in Thailand.
6. Resuits from activities 1, 2, 3, 4, 5, 6 were publicized. Activities 1 and 2 were published in technical reports, bulletins and distributed to concerned organizations and individuals. Activity-4 was presented at the World Aquaculture-90 conference at Halifax, Nova Scotia, Canada. Activities 3, 5 and 6 were presented at the Third Seminar on Living Aquatic Resources, Chulalongkorn University. Another seminar and workshop on Aquaculture Feed Production Technology was also organized at Chulalongkorn University. Participants of the seminars and conference expressed great interest in the developed technology and information.
7. Shrimp farmers benefit directly from the new technology and information. Technology transfer enables them to produce feeds for their own use through the co-operative group facility.
8. Information on raw material quality, production procedures and equipment efficiency directly benefit the local feed manufacturers and the local shrimp farmers.

B. Recommendations

1. Rearing ***P.monodon*** in ponds to produce broodstock is recommended.
2. Rearing ***P.monodon*** in ponds for broodstock will be successful only if water quality is controlled as well as soil bottom quality, disease control, proper feeding and stocking.
3. ***P.monodon*** broodstock from ponds should be treated for parasites and diseases with antibiotics before induced spawning by eyestalk ablation. The spawners in the tank should be fed with fresh meal.
4. Information obtained via this project should be publicized and/or transferred to the target groups so that the highest benefit could be achieved among feed manufacturers and shrimp farmers.

1. Sub-Project Title : **Technology Transfer to Increase High Value Shellfish Seeds (026)**

2. Responsible Agency : Coastal Aquaculture Division, Department of Fisheries

3. Life of Project : 1988-1990

4. Implementation Site : Prachuap Khiri Khan Research and Developing Center for Coastal Aquaculture

5. Approved Budget :

Loan	US $	103,318	
Grant	US $	20,400	
Total	**US $**	**123,718**	

6. Actual Expenditures :

Loan	US $	87,932	
Grant	US $	15,579	
Total	**US $**	**103,511**	**or approximately 84% of approved budget**

7. Sub-Project Objectives :

7.1 Increase DOF capability to operate a commercial scale hatchery and nursery for large oysters.

7.2 Demonstrate and train fishermen on nursery and hatchery techniques.

7.3 Hatch high value shellfish species such as pearl oyster, scallop, fan shell and giant clam, and abalone.

8. Accomplishments :

A. Research Activities

1. Improvement of oyster hatchery and nursery techniques.

This study for improving oyster hatchery and nursery techniques included such activities as :

1.1 Management of seawater systems and hatchery facilities

Seawater used in mollusc hatchery was processed through sand filters then passed through 5-10 microns filtrate and 1 micron filter bag. It was then run through ultraviolet light treatment before being used.

The improvement of hatchery seawater system was done in several steps. A bacterial sterile system was set up to eliminate pathogens in the hatchery. The pipe line was restructured so that seawater could be entirely drained out from the pipe every day after work. Chlorinated sea water was injected through the pipe line system once a week. After the improvement of the seawater pipe line system, improved results of oyster larval rearing were obtained.

1.2 Broodstock maintenance

The oysters from various culture areas, such as Surattani and Ranong, were collected and transported to Prachuap Khiri Khan Coastal Aquaculture Development Center where they were held on wooden frame trays hanging in earthern fish ponds or canals. Every oyster was tagged so that spawning behavior could be traced. The information was collected year by year so that breeding selection could be done in the future.

The experiment on oyster broodstock conditioning was performed by means of running untreated seawater through oyster holding trays with supplemental feeding of mass culture algae for 2-4 weeks before spawning induction. The result showed a higher percentage of response to spawning

induction in the conditioned group a higher quantity of eggs per spawner and also improved larval development and vitality, than in the non-conditioned group.

1.3 Setting techniques for oyster larvae

Several setting materials were tried during the setting phase of the larvae, i.e. oyster shell PVC plate and plastic sheets. The young spats were detached with a soft brush to get single spat. The setting and metamorphosis rate, including the mortality rate, were studied to determine the appropriate setting technique.

Result showed that PVC plates are a good material to use for oyster setting in the hatchery. After removal the average mortality of the spat was 7.5%. This rate depended on individual personal manipulation, and the density of oyster spat on the plate.

1.4 Nursery techniques for oyster spat

1.4.1 Indoor Nursery : The young oyster spat was reared indoors with an upwelling system; two trials were made using :

– An open upwelling system : This system was composed of a 80 cm in diame ter, 50 cm high upwelling tank. Seawater flowing through the system was discharged immediately.

– Closed upwelling system : A smaller upwelling tank, 10 cm in diameter and 30 cm in height was used. Seawater used in this nursery was recycled through the system by means of an electric pump.

Both systems could rear young oyster spat up to 2-3 mm size. Although the closed system needed a lower quantity of algae and seawater, the system has to be very clean. However, the open flow system had lesser deposits of waste products which is an advantage.

1.4.2. Outdoor Nursery : The outdoor nursery process was accomplished by using natural seawater from ponds or canals near the hatchery for rearing young oyster spat. The nursery area was covered with plastic net to decrease sunlight heat and also reduce algae bloom in the rearing tank. The upwelling system was set up in concrete or fiber glass tanks. Optimal of spat density, seawater flow rate, oyster spat growth rate and optimum size of spat used were studied.

The results showed that seawater used in the system could be pumped from shrimp or fish ponds where phytoplankton were abundant so that the spat could feed on the plankton supplemented with algae from mass culture. The suitable size of young spat to be reared in this system should be at least 500-600 um, and reaching 15-25 mm in size within one month.

2. Growth rate of hatchery produced oyster spat

The 0.5-0.8 cm hatchery produced oyster spat were cultivated under various conditions some were raised in the canals and ponds near the hatchery, while some were kept in the coastal sea. The results showed that the growth rate was satisfactory for oyster grown in the canals and ponds; lower growth rates and fouling problems were obtained for the oyster grown in the sea.

3. Feasibility study on commercial oyster hatchery

The cost of hatchery produced oyster spat was analysed for each step of the process, and also the financial feasibility was determined for oyster farmers to increase their production by using hatchery spat. The results showed that to operate an oyster hatchery required high investment and skillfull people.

Because of the low price of oyster spat compared to the high investment and long operational period of the hatchery process, a private hatchery is unprofitable at present. However the private sector could make money by setting up a nursery using the young oyster spat from the government hatchery and growing them to the desirable size for sale to oyster farmers.

Presently, the hatchery of Prachuap Khiri Khan Coastal Aquaculture Development Center can produce ready-to-set oyster larvae (eyed larvae) and many millions of young oyster spat each month. However, given the limitation of space, labor and materials, the hatchery can not produce enough large oyster spat to meet the demand of oyster farmers.

4. Experiment on hatchery propagation of other economic molluscs

4.1 Pearl oyster

The oyster species used in this project were the gold lipped pearl oyster Pinctada maxima and the wing oyster Pteria penguin. Because of obstacles on spawner collection during the

project period, the experiment could deal only with Pinctada maxima. Several methods of induced spawning was tried, including a chemical treatment such as ammonium hydroxide and serotonin. These two chemical treatments resulted in spawning induction but the larvae were unable to pass through the metamorphosis stage. The other method used was air exposure alternated with seawater which resulted in both successful induced spawning and larval rearing. The success in breeding gold-lipped pearl oyster is considered to be the most important result of the pearl oyster hatchery work in Thailand.

4.2 Abalone

4.2.1 Experiments on culturing : The Taiwanese Abalone, Haliotis diversicolor was introduced to Prachuap Khiri Khan hatchery. A raceway concrete tank with continuous seawater flow system was used for the rearing. Various species of domestic algaes were fed and growth rate and mortality rate were recorded. The results showed that the abalone grew from 15.5 mm in width and 27.6 mm in length, to 26.7 mm in width and 42.3 mm in length in 9 months. The average growth rate was 1.24 mm and 1.63 mm for width and length of abalone shell, respectively; the mortality rate was 69.6%.

4.2.2 Experiments on induced spawning : The native abalone Ealiotis asinina and H.ovina were collected and spawning was induced in the hatchery. Satisfactor results of induced spawning and larval rearing were obtained with both species even though survival rates were rather low.

B. Technical Assistance and USA Observation tour.

1. The mollusc culture expert from University of Washington at seattle, Dr.Kenneth K.Chew, came to impart his knowledge and recommendations on mollusc culture in Thailand for two weeks August 18-30, 1982.

2. Two biologists from the Department of Fisheries toured several USA commercial mollusc culture labs and hatcheres and in Canada June 8 - July 3, 1982.

9. Benefits from the ATT project:

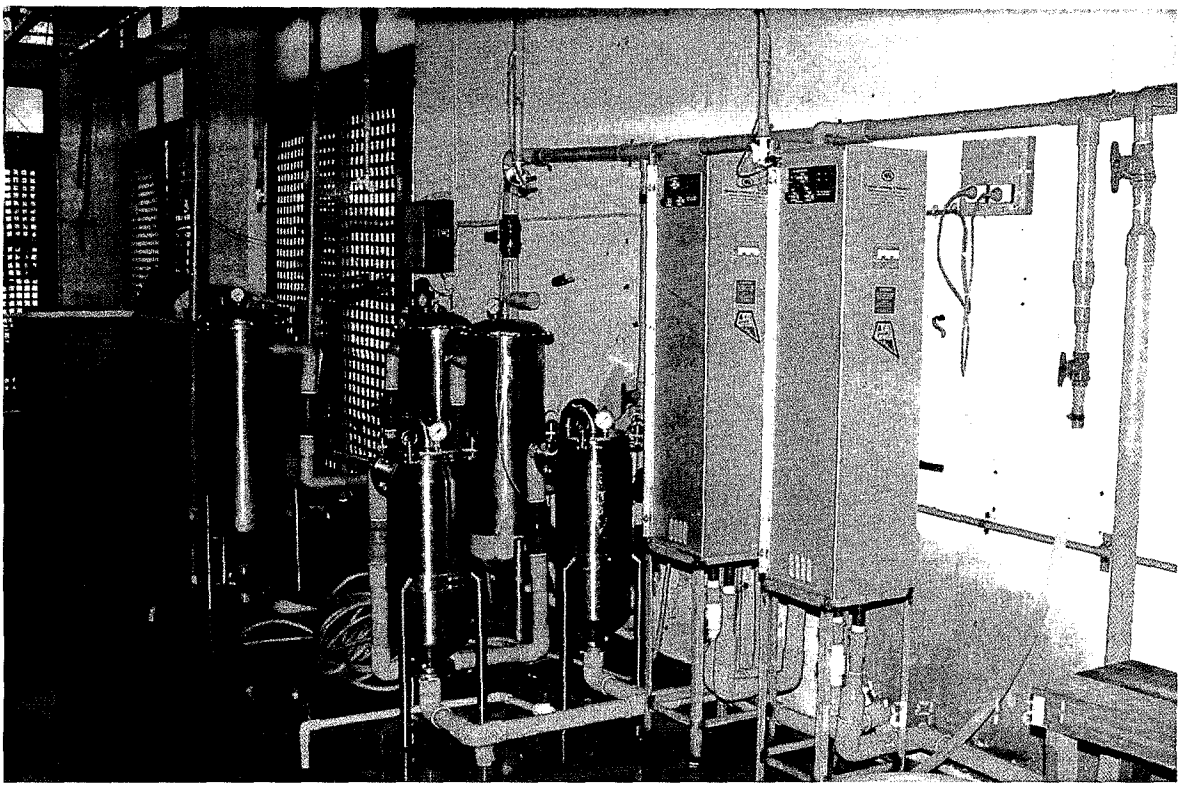
9.1 The improvement of oyster hatchery production. After the project, Prachuap Khiri Khan hatchery can distribute viable production to oyster farmers in Surattani and Ranong. These hatchery products lessen the serious problems of natural oyster spat shortages.

9.2 After the project, several prospective investors in commercial mollusc production were identified for pearl oyster, abalone and other species presently under study.

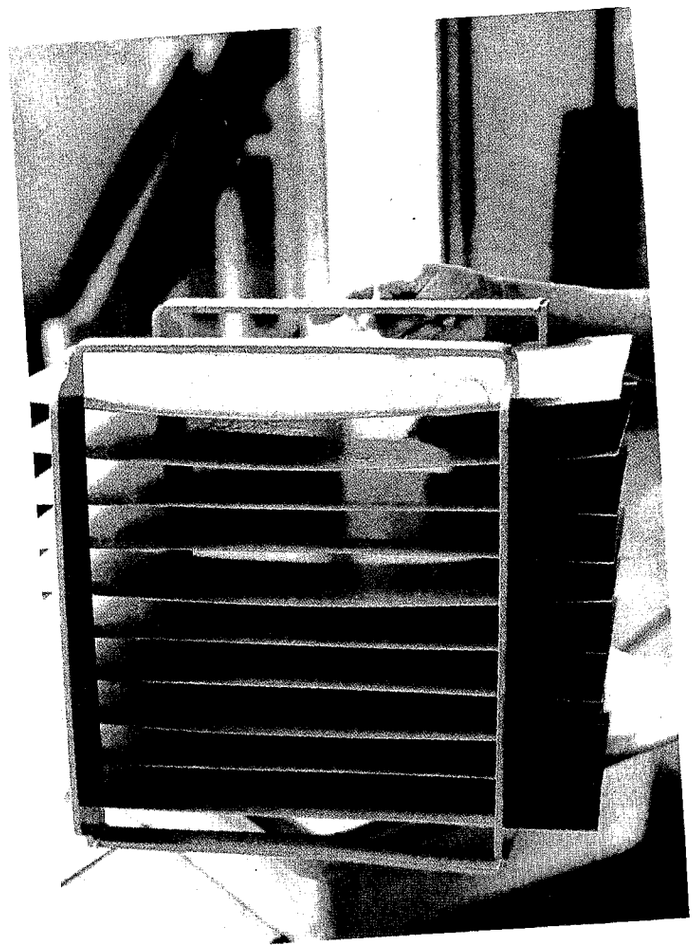
9.3 The experience gained from the study tour on mollusc culture and hatchery in USA and Canada has been a great advantage as we have adapted their techniques to our conditions; finally we can promote commercial mollusc culture in Thailand.

10. Recommendations and Suggestions :

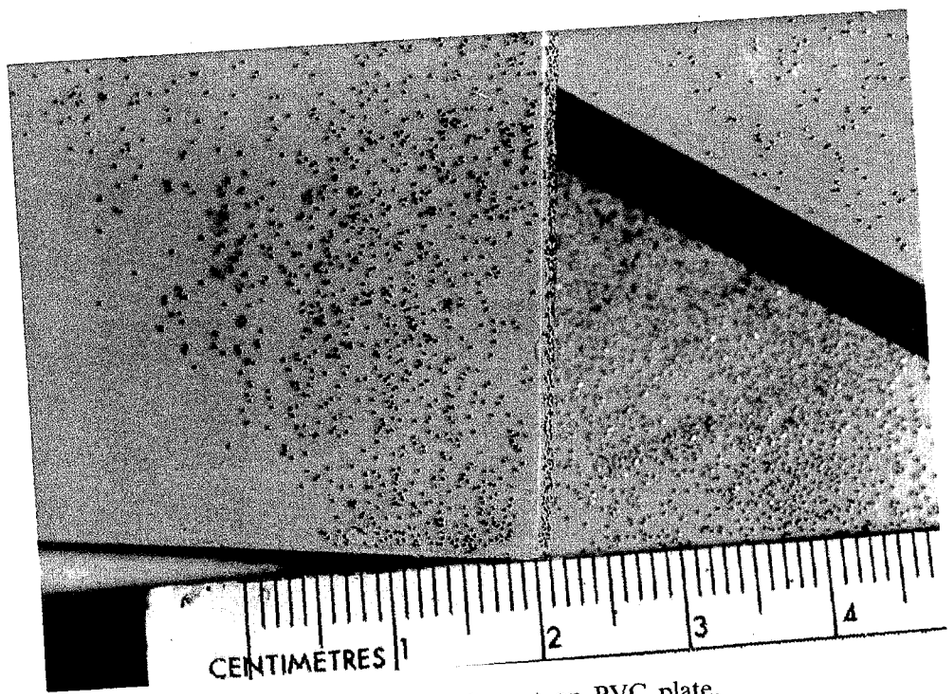
The mollusc program under ATT sponsorship is considered to be one of the most valuable cooperative projects. The project has expanded our knowledge and introduced new useful technology to develop our mollusc culture. However, the work under the project would get the maximum benefit it the schedule for funding was strictly controlled. Delays on contracts and cooperation such as bringing out the USA expert and budget management were obstacles which obstructed implementation of the project.



A seawater system in a mollusc hatchery using 1 micron filter bag and ultraviolet light.

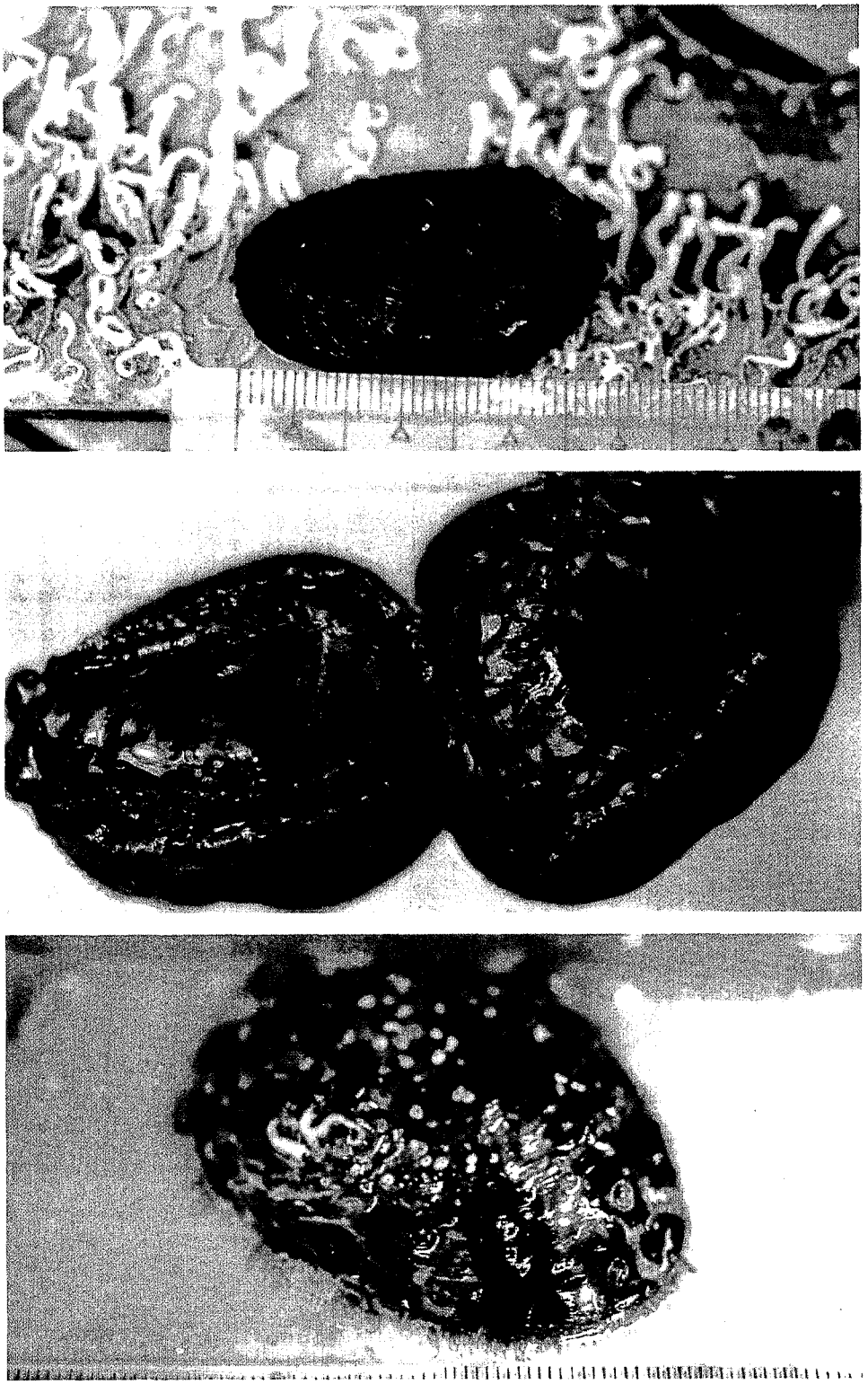


Oyster shell PVC used during the larval setting phase.



The young spats also set on PVC plate.

Hatchery propagation of Pinctada maxima oysters



Various species of Abalone:–

A. Haliotis diversicolor

B. H. asinina

C. H. ovina

1. Sub-Project Title : **Improving Control of Swine Dysentery thru Use of Rapid Diagnostic Technique (ELISA) (027)**

2. Responsible Agency : Veterinary research Division, Department of Livestock Development

3. Life of Project : 1988-1989 (extend to 1990)

4. Implementing Sites : (1) Veterinary Research Division
(2) Swine raising farms in the central region of Thailand

5. Approved Budget :

Loan	US $	34,361
Grant	US $	13,762
Total	**US $**	**48,123**

6. Actual Expenditures :

Loan	US $	31,133	
Grant	US $	11,912	
Total	**US $**	**43,045**	**or approximately 89% of approved budget**

7. Summary of Problem and Objectives :

A. Problems :

Swine dysentery (SD) is a mucohemorrhagic diarrheal disease affecting pigs of all ages. Treponema hyodysenteriae, an anaerobic spirochete, is the etiological agent of the disease. This disease occurs throughout most swine raising areas of the world including Thailand where swine production has been modernized to meet international standards. SD is widespread especially on commercial farms wherever pigs are kept in large confinements mostly in the central part of Thailand. It is undoubtedly costly to the national swine industry mainly from loses of growth and poorer feed conversion, although mortality may reach 30% occasionally.

Asymptomatic pigs recovered from SD are capable of transmitting the disease to susceptible pigs. Detection of these carrier pigs, however, is difficult. The control of SD would be assisted by a sensitive and specific test to detect serum antibody to ***T. hyodysenteriae*** especially where the disease is not apparent or suppressed by antibiotics. Method of diagnosis of this disease has not been successful apply. Joen et. al (1982) demonstrated ELISA (Enzyme-Linked Imunosorbent Assay) technique that is sensitive for detecting serum antibody to ***T. hyodysenteriae*** of swine herds. This report describes the application of an ELISA for diagnosis of swine dysentery in swine herds in the central region of Thailand where this disease has been reported for years.

B. Objectives :

(1) To develope rapid method for detecting exposure to ***T. hyodysenteriae.***
(2) To minimize the incidence of swine dysentery in Thailand.

8. Accomplishments :

8.1 Research Activities

(1) Serotype incidence of ***T. hyodysenteriae*** isolated from swine farms in central area.

Table 1. Isolation and serotyping results of ***T. hyodysenteriae*** in suspected swine by provinces.

Provinces	No. of collected fecal samples	No. of Positive samples	No. of positive samples subject to serotyping	Serotype of ***T. hyodysenteriae***
Rachaburi	136	16	7	2
Nakornpathom	173	29	12	2
Angthong	30	13	5	2
Cholburi	46	–	–	–
Chacherngsoa	24	–	–	–
Lobburi	1	1	1	2
Bangkok	1	1	1	2
Samutprakarn	29	–	–	–
Rayong	20	–	–	–
Prachinburi	18	–	–	–
Chantaburi	10	–	–	–
Petchaburi	20	–	–	–
Supanburi	10	–	–	–
Saraburi	32	–	–	–
Total	550	60	26	–

The isolations were performed by using selective media as described by Kunkle and Kinyon (1988) and serotyped according to the method described by Baum and Joens (1979).

(2) Application of ELISA technique to diagnose swine dysentery.

Table 2. ELISA and isolation results in swine herds naturally affected by ***T. hyodysenteriae*** (with clinical symptoms)

Herds	No. of pigs samples	ELISA (B204)				Isolation result for ***T. hyodysenteriae***			
		+	%	–	%	+	%	–	%
No. 1	7	3	(42.9)	4	(57.1)	2	(28.6)	5	(71.4)
2	10	10	(100)	0	(0)	10	(100)	0	(0)
3	12	10	(83.3)	2	(16.7)	8	(66.7)	4	(33.3)
4	6	6	(100)	0	(0)	5	(83.3)	1	(16.7)
5	5	4	(80)	1	(20)	5	(100)	0	(0)
6	11	9	(81.8)	2	(18.2)	5	(45.5)	6	(54.4)
Total	51	42	(82.4)	9	(17.6)	35	(68.6)	16	(31.4)

Table 3. ELISA and isolation results in swine herds un-affected by ***T. hyodysenteriae*** (without clinical symptoms)

Herds	No. of pigs samples	ELISA (B204)				Isolation result for ***T. hyodysenteriae***			
		+	%	–	%	+	%	–	%
No. 1	25	0	(0)	25	(100)	0	(0)	25	(100)
2	10	0	(0)	10	(100)	0	(0)	10	(100)
3	14	1	(7.1)	13	(92.9)	0	(0)	14	(100)
4	10	0	(0)	0	(0)	0	(0)	0	(0)
Total	59	1	(1.7)	58	(98.3)	0	(0)	59	(100)

Table 4. ELISA and isolation results in swine herds exposed to ***T. hyodysenteriae*** (subclinical symptoms)

Herds	No. of pigs samples	ELISA (B204)				Isolation result for ***T. hyodysenteriae***			
		+	%	−	%	+	%	−	%
1	17	17	(100)	0	(0)	6	(35.4)	11	(64.7)
2	15	10	(66.7)	5	(33.3)	4	(26.7)	11	(73.3)
3	15	14	(93.3)	4	(6.7)	0	(0)	15	(100)
4	15	15	(83.3)	3	(16.7)	0	(0)	18	(100)
5	20	8	(43.3)	12	(56.7)	10	(50)	10	(50)
Total	85	64	(75.3)	21	(24.7)	20	(23.5)	65	(76.5)

ELISA technique was performed by using Lipopolysachiaride (LPS) extracted from cells of ***T.hyodysenteriae*** strain B 204 as serotype 2 specific antigen described by Joens et. al (1982). An optical density value equal or greater than reference negative sera was considered as a positive result.

Isolation was carried out by the method cited in Table 1. Comments

Results showed that :

1) In suspected areas of swine dysentery (Table 1.), 60 individual pigs out of 550 tested 11% positive according to isolation method that led to further investigation in applying the ELISA method and symptomatic observations.

2) ELISA results (Table 2.) are well correlated with the number of isolated cases in swine using clinical signs but the ELISA was sensitive than isolation method.

3) In contrast, (Table 3.) swine with no record of infection of ***T. hyodysenteriae*** provided high percentage of negative results tested by both ELISA and isolation techniques.

In conclusion, detection of serum titre by using ELISA method should be applied to diagnose swine dysentery in Thailand especially in herds that show symptomatic evidence that normally is complicated with other diarrheal diseases. In the farms where symptomatic evidence was not found and also ***T. hyodysenteriae*** almost absent, e.g. carriers or subclinical infections, the ELISA technique can be applied but not as accurately as in the herds clearly showing clinical signs. This is shown in Table 4. that 75% of serum antibody was detected by ELISA compared with 24% detection by the isolation method in herds with subclinical symptoms.

8.2 Technical Assistance and Training

(1) Services rendered by expert Dr. Shannon C. Whipp, from National Animal Disease Centre, Iowa
- Advised on research planning
- Developed modern diagnostic technology for SD by isolation
- Discussed SD problem and control program
- Developed Thai ability to run an ELISA test utilizing the LPS antigen produced to detect swine which have SD

(2) Development of ELISA technique was be enhanced by technical knowledge from Dr. Lynn. A.Joens of University of Arizona, who tranfered this technology to DOLD staff as follows :
- Evaluate specificity and standardization of LPS antigen
- Develop method of serotyping of ***T. hyodysenteriae***
- Implementation of ELISA for SD
- Resolved several technical problems in laboratory
- Provide reference positive and negative sera for ELISA testing

(3) The participant obtained new technologies for diagnosis of swine dysentery by isolation, preparation of LPS antigens and convalescence sera for developing ELISA technique to detect serum antibody to ***T. hyodysenteriae*** in swine herds, these may be applied in a control program of swine dysentery in Thailand.

9. Benefits and Recommendations :

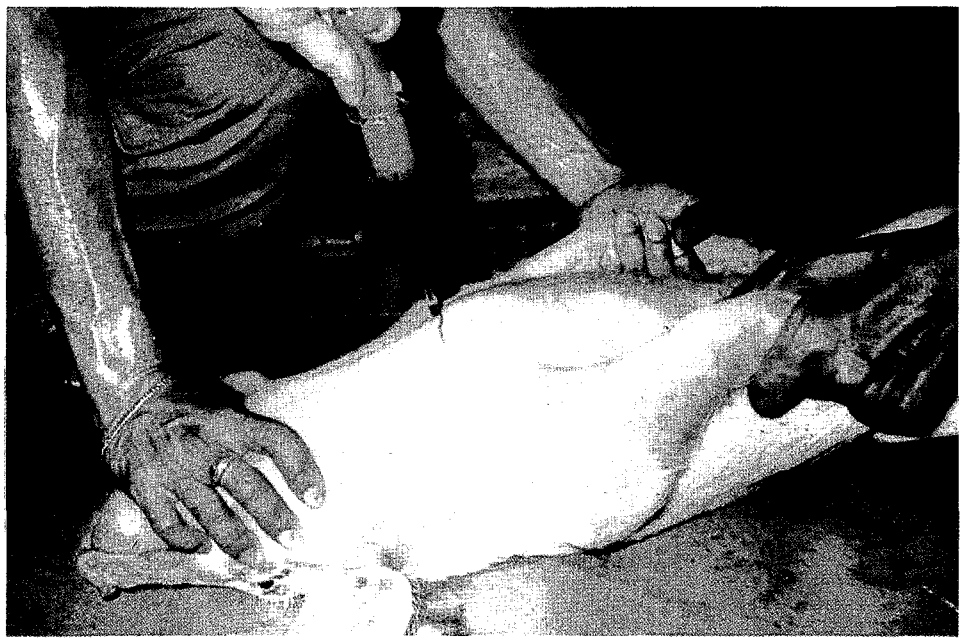
9.1 Benefits

In future, to control swine dysentery the ELISA method should be applied to determine the prevalence of this disease among herds in suspected or non-suspected areas e.g. having serum profile for weaning and growing pigs prior to any application of effective control program such as medication or vaccination. This program can be transferred to both commercial interest or farmers to solve dysentery problems in swine by either direct communication e.g. seminars, workshops or laboratory services through the government or private sector.

9.2 Technology Transfers

(1) Modify ELISA method to other laboratories to make swine dysentery diagnosis.
(2) Educate farmers and officials to do serum profiles among herds.
(3) Provide laboratory services to farmers or government agencies.
(4) Training government and private veterinarians to serve farmer requirement.

Piglets artificially infected with swine dysentery by inoculating of *T. hyodysenteriae*



Blood sample collection from infacted pig for detecting serum titre by ELISA technique

1. Sub-Project Title : **Biological Control of Insect Pests (030)**

2. Responsible Agency : Entomolgy and Zoology Division, Department of Agriculture
Plant Protection Service Division, Department of Agricultural Extension

3. Life of Project : Feb. 1988 - Jan. 1990

Approved Budget :

Loan	US $	247,213	
Grant	US $	48,900	
Total	**US $**	**296,113**	

5. Actual Expenditures :

Loan	US $	173,722	
Grant	US $	34,508	
Total	**US $**	**208,230**	**or approximately 82% of approved budget.**

6. Summary of Problems and Objectives :

A. Problems :

The human health and environmental problems associated with the use of chemical insecticides are well known and are present in Thailand where insecticides have been used extensively and in discriminatively for over 20 years in attempting to overcome insect pest infestations. Insecticides are not only directly toxic to man, animals and plants but also indirectly pollute the environment especially when misused or overused and applied by inexperienced farmers. The effects pass to all consumers including beneficial animals and insects who are beneficial predators.

Therefore, this project is to conduct datailed studies of effective natural enemies and to develop mass culture techniques technologies transferred from the U.S.A. to induce biological control of economic crop pests or to integrate the measures with other control methods such as use of plant resistance or selective use of insecticides. This is to obtian the highest benefits in the pest control program as well as to reduce the chemical harzard.

B. Objectives :

1. To improve and develop mass production of natural enemies such as insect parasites, predators entomophagous nematodes fungi, viri and bacteria to enhance the biological control program or to integrate these biotic factors with other economic control measures such as the use of plant resistance, selective insecticides etc. for obtaining the most effective pest management program.

2. To transfer the latest technology to extension officers as well as farmers and the private sector.

7. Accomplishment :

A. Research Activities

1. The Biological Control of Longan Stink Bug

The wild silk worm (***Philosamia recini*** Boisd.) which is one of the alternate hosts of the Longan stink bug egg parasites ***Anastatus*** sp. nr. ***japonicus*** was reared for production of eggs during

Nov. 1988 - March, 1989. There were 3 generations of the silk worm obtained and 10,000 silk worm individuals produced per generation. The eggs collected from female silk worm adults of each generation yield about 400,000 parasites which were released in the demonstration longan field at the rate of 5,000 - 10,000 parasite individuals per rai.

The demonstration field was a longan plantations of 96 rai belonging to 22 farmers and located in Umong District, Amphoe Muang, Lampoon Province. Parasite were release twice; once in February and once in March 1989 synchronized with one application (spot treatment) of synthetic pyrethroid (cyhalothrin) especially on Longan trees where more than 200 stink bugs were observed. The treatment suppressed the population of the stink bugs below the economic threshold level. Nine demonstration trials of 90 rais in cooperation with the Department of Agricultural Extension officers were installed. There were 4 releases of the stink bug egg parasites or a total of 1,000,000 Parasite individuals along with mechanical destruction of the stink bugs. Effective control of the outbreak was obtained.

2. The Role and Efficiency of Predatory Stink Bug in Controlling the oil Palm Leaf-Eating Caterpillar

The tests were carried out by using the 3rd instar of the predatory stink but (***Eocanthecona furcellata*** Wolff) at different rates (treatments) i.e. 5, 10, 15 and 20 individuals preying on 50 2nd to 3rd instar oil palm leaf-eating caterpillars, ***Darna furva.*** The highest predatory efficiency was found using 15 predators. The average predator efficiency was 48 - 49 prey per day (or 293 prey per 6 days). The other efficiency rates were 20, 10 and 5, respectively. The 3rd instar nymph of the predator at the age of 2 days had the lowest efficiency i.e. 23 prey per day with no statistical difference from the average predation per day of the 3rd instar nymph at the age of 3 to 6 days.

However, it was also found that in a field cage with the lowest rate (i.e. 1 predator to 5 prey) the nymph has a high predatory efficiency of 98% within 3 days.

3. Population Fluctuation of Citrus Leaf miner and Its Natural Enemies on Pomelo.

3.1 The investigation of important species of natural enemies used in controlling pomelo leaf miner ***(Phyllocnistic citrella)*** populations revealed that there were 3 important parasitic Hymenoptera (not yet identified) i.e., 2 species of larval parasites and 1 species of pupal parasite. In the rainy season which was the peak of the leaf miner outbreak, the larval and pupal parasites found were 40 and 31 percent effective, respectively. These parasites were considered the important biotic factors to be used controlling the leaf miner populations.

3.2 Biology and Efficiency of Predatory Neuropterans, ***Chrysopa basalis*** and ***C. sinensis.***

A laboratory test indicated that the native species, ***C. basalis,*** had a shorter life cycle (21 ± 2.45 days) than the introduced species from China, ***C. sinensis,*** (23 ± 3.26 days). These 2 species had similar average durations of eggs, 1St and 2nd nymphal stages of 3, 2 and 2 days respectively. The difference was found in the 3rd nymphal and pupal stages at which the ***C. sinensis*** spent some longer periods i.e. 5 and 10 days for the 3rd nymphal and pupal stages respectively and 4 and 9 days for those of ***C. basalis*** respectively.

For predatory efficiency in laboratory tests by preying on the eggs of ***C. cephalonica;*** it was observed that ***C. sinensis*** had a higher average predatory rate i.e. 673 eggs per individual than the ***C. basalis*** which had the average rate of 424 eggs per indivudual. Therefore, ***C. sinensis*** was recommended for mass culture and control of Pomelo Leaf Miner.

4. Integrated Control of Cotton Boll Worm (Weevil)

The tests was carried out in 3 farmer's cotton fields, each 60 rais, in Amphoe Saiyoke, Kanchanaburi province. The first treatment was a chemical application only and the fields were looked after by the farmers. The second treatment was integrated pest management where the egg parasites of cotton boll worm ***Trichogramma confusum*** were released in conjunction with viral and chemical sprays. The first treatment gave cotton yields of 384, 326 and 300 kg per rai for farmer

1, 2 and 3, respectively. In the second treatment there were 1,200,000 egg parasites ***(I. confusum)*** released and the percentage of parasitization was observed to be 50 - 60%. After the integration with viral and chemical sprays, cotton yields of 560, 450 and 283 kg per rai for farmer 1, 2 and 3 were obtained, respectively.

The integration of biological methods with chemical sprays will gave a higher cotton yield than the application of chemical sprays alone.

5. Effects of Insecticides for Controlling Cotton Boll Worm on the Egg Parasites ***Trichogramma confusum.***

This experiment was to find the effective rates of insecticide application to control cotton boll worm ***Heliothis armigera*** and to determine the safe periods for using egg parasites. ***Trichogramma confusum.*** In this experiment the rice moth eggs that had been parasitized by ***T. confusum*** for 4 - 7 days were tied on cotton plants both in the laboratory and in the field. There were 10 insecticides under high volume sprays used; viz, Atabron 20 ml/20 lt water. Abamectin + Thiodan 5 + 50 ml/ 20 lt water, Bulldock KL 60 ml/20 lt water, Karate 20 ml/20 lt water, Donco 20 ml/20 lt water, Sperpa + Lavin 8 + 30 ml/20 lt water, Baythroid T.M. 60 ml/20 lt water, Polythrin C + Bolstar 50 ml/20 lt water, Concord 24 ml/20 lt water and Folimat 40 ml/20 lt water.

Insecticidal degradation was greater in the field than in the laboratory and the safe period for parasite eggs was found to be 4 - 5 days after egg release rather than after 6 - 7 day release. However, under laboratory conditions the safty period was prolonged to 7 days.

Insecticides that proved to be safe for the egg parasites were Donco, Baythroid, Atabron, Folimat, Abameetin + Thiodan, Concord and Karate. While the most dangerous insecticides to the egg parasites were Polythrin C + Bolstar, Bulldock KL and Sherpa + Larvin.

6. Biological control of sugarcane borer

6.1 Efficiency of Trichogramma confusum in controlling the sugarcane borer.

The egg parasites were able to keep the borer populations under the economic threshold level at the rate of 160,000 individuals per release with 4 releases per plot (the experimental plot size was 3 rai). The average of the percentages of parasitization of borer in test fields compared with the control (non-released) field were 70% and 25% respectively, while the yield at harvest were 7.0 and 1.0 ton/rai. and the sugar production was 5.18 and 0.72 ton/rai, respectively.

6.2 Effects of insecticides used in controlling the sugarcane borer on the development of the egg parasites,

Trichogramma confusum Viggiani (China strain)

It was found that endosulfan and monocrotophos at the rates of 250 ml and 35 ml per 20 lt of water respectively hod the least effects on the development of parasite larvae at the age of 3 days. The mixture of monocrotophos and cypermetrin and the dual application of cypermetrin and monocrotophos at the rates of 30 ml, 13 ml and 35 ml per 20 lt of water had the least effects on the pupae of the parasite at their age of 7 days.

7. Biological control of leucaena psyllid, ***Heteropsylla cubana*** by predatory Coccinallid, ***Curinus coeruleus.***

7.1 Life cycle of ***C. coeruleus***

At 30° ± 2°C, ***C.*** coeruleus had the egg, larval, pupal and adult durations of 5 - 7 days, 21 - 30 days, 7 - 14 days and 22 - 112 days respectively with the average life cycle of 54 - 163 days. At 25° ± 2°C the life cycle was shorter i.e. 57 - 76 days while the egg, larval, pupal and adult durations were 5 - 7 days, 20 - 25 days, 7 - 14 days and 25 - 30 days respectively, ***C. coeruleus*** develops better at 30°C than 25°C and that it is adapted the normal day temperatures of Thailand.

7.2 Predatory Efficiency Test of ***C. coeruleus*** on ***H. cubana.***

Laboratory tests indicated that the 1st to 4th instar larvae of Coccinellid predator, ***C. coeruleus,*** preyed on the average of 1,600 - 15,000 eggs of H. cubana

(Mean of 4,300 eggs). When the larvae were allowed to feed on the 2nd and 3rd nymphal stages of ***H. cubana,*** the average preyed individuals were 8,200 - 16,000 (Mean of 10,400 individuals). It was concluded that one ***C. coeruleus*** was one of the most efficient predators and should be mass cultured for controling ***H. cubana.***

7.3 Mass rearing techniques for predatory Coccinellid ***C. coeruleus.***

The preferred ovipositing material among all 6 tested materials was crepe paper used as the supporting inner layer of the carton used for packaging of fluorescent bulds. The eggs of ***C. coeruleus*** were found abundantly deposited and the total number of eggs observed were 1.5 times, 4.4 times, 6 times, 2.3 times and 60 times larger than those found in Leucaena leaves, normal draft paper, tissue paper, muslin sheet and bamboo stem respectively. However, in this comparative test, there were no eggs on Leucaena stem.

For rearing cages, the normal insect net-cage yielded a low production compared with a cylindrical glass container (30 cms. in diameter and 45 cm heigh) covered with a muslin sheet.

8. The utilization of Nuclear Polyhedrosis Virus (NPV) in controlling Cotton Boll Worm ***Heliothis armigera*** Hubner.

8.1 Development of a Mass-culture method for the NPV.

The development aimed at the labor cost reduction through the use of vaccum machine in collecting the viral diseased and dead cotton boll worm larvae in substitution of manual operations. The result was that there were 3 liters of NPV purified per week and the amount was adequate for the use of many large scale applications.

8.2 The utilization of NPV in controlling Cotton Boll Worm, ***Heliothis armigera.***

The experiment was on the integration of the NPV with chemical sprays and was carried out in 2 cotton fieds, of 20 rai each and 3 cotton fields of 30 rai each in Amphoe Sai-Yoke, Kanchanaburi province in crop year 1987/88 and 1989/90, respectively. The dual use of NPV at the standard concentration of $2 + 10^9$ crystals/ml at the rate of 100 - 200 ml/rai gave good control of the cotton boll worm as well as its integration with chemical sprays when cotton aged 30 - 60 days and 85 - 110 days, for cotton aged 60 - 80 days, the dual use of chemical was recommended.

8.3 The utilization of NPV in controlling Cotton Boll Worm in tomato.

The experiment was within the tomato plantations of 3 rais in Amphoe Cha-am, Petchaburi province, where there was severe damage of ***H. armigera*** in 1988 and 1989. The NPV can be used dually in substitution of chemical sprays at the rate of 30 ml/20 lt. of water and sprayed at every 5 days intervals when the population of the Cotton Boll Worm was at the average of 20 larvae per 100 tomato plants. In the plantation where there was a very serious outbreak of the Cotton Boll Worm i.e., 60 larvae/100 tomato plants, NPV sprays at 3 days intervals are recommended.

8.4 The utilization of NPV. in controlling Cotton Boll Worm in green okra.

The NPV suspension was sprayed on green okra, ***Hibiscus esculentus,*** grown for export to Japan in order to reduce the insect pest damage and the chemical residues. The tests were run in 1987 in an okra plantation of 1 rai in Nakorn Pathom province for the possible use of the NPV. In 1988 and 1989, the crop plantation of 5 rais in the same area for the integrated sprays of the NPV suspension and some other chemicals. The result indicated that the NPV at the rate of 30 ml/20 lt. of water at every 5 days intervals gave a good control of ***H. armigera.***

9. Studies of Entomophagous nematodes, ***Neoplectana carpocapse,*** in controlling Bark Eating caterpillar, ***Cossus*** sp. in Longong and Langsat.

9.1 Mass culture by using artificial media.

The study indicated that the production of ***N. carpocapse*** by using dog food was better than the use of host insect. The production cost reduced from 18 baht/lt to 5 baht/lt at the nematode concentration of 2,000 individuals/ml.

9.2 Preservation of Nematodes.

The use of sponge for nematode preservation in substitution of water, the conservative media, was the most effective method for it required small storage, created least transport problems and kept the nematode viable for no less than 12 months at the control efficiency of 80%.

9.3 Control efficiency of Nematodes in Field Condition.

The experimental fields were Longong and Langsat plantations of Narathiwat, Songkhla, Trang, Yala, Chanta Buri, Trad and Nakorn Nayok provinces. It was found that spraying the nematode suspension of 2,000 individual/ml at the rate of 5 - 7 lt/ tree gave the good control of 70 - 80%. The spray applications used knap-sack sprayers or high-volume motorized sprayers. The optimum timing for the control was June to July as well as the months in between the rainy and the cold seasons or before the flowering period.

10. Control of Vegetable Pests by ***Bacillus thuringiensis.***

10.1 From the comparative study of the efficiencies of the isolated bacterial strains; MU-1, TKP-1 and TNP-1 and the commercial products; Thuricide and Bactospine to control Diamond back moth, ***Plutella Xylostella*** and cabbage looper, ***Trichoplusia ni*** in Kanchanaburi province, it was found that Bactospine gave the best control result. Next to Bactospine was the MU-1. This was probably due to the better formulation of the Bactospine.

11. Control of Oil Palm Leaf-Eating Caterpillar ***Darna furva*** using ***Bacillus thuringiensis.***

There were 4 out of 11 bacterial strains of ***B. thuringiensis*** that gave 80 - 90% control of the population of ***D. furva*** while the other 6 strains yielded the control result of 50 - 60%. The effective strains will be further investigated for the appropriate application concentration.

12. Study on Effectiveness of the Green muscadine fungus, ***Metarhizium anisopliae,*** Thai and Philippines strains on ***Rhinosceros beetle, Oryctes rhinosceros.*** The result of this experiment were as follows :

12.1 The Thai strain gave a better control than the Philippines strain. (although they were not statistically different)

12.2 The Thai strain was more virulent than the Philippines strain at low application concentration.

12.3 The recommended application rate was 100 - 300 gms. of ***M. anisopliae*** (Thai strain) grown on rice substrate to each compost pile sized 2 × 2 × 0.5 m.

13. Efficiency Tests of NPV and Some Botanical Insecticides to Control ***Heliothis armigera*** and ***Spodoptera exigua.***

There was more insect mortality in ***H. armigera*** than ***S. exigua*** and the treatment of the mixture of 1 gm. of Derris elliptica and 1 million NPV crystals gave the highest mortality in both insect species.

14. Efficiency of Natural Enemies in Controlling Mung bean, Soy bean and Peanut pests.

14.1 The mungbean of Kamphangsaen 1 variety was grown at the plant spacing of 50 × 20 cms. in 2 treatments each of which consisted of 20 experimental plot sized 3 × 10 m. The first treatment was with no insecticide application while the second treatment was also with no insecticide and surrounded by 3 border rows of sorghum of U-thong variety. The result showed that the first and the second treatments had the harvest yield of 30,255 kgs. and 44,075 kgs. respectively.

14.2 The soybean of S.J. 5 variety was grown in the same pattern as was the mungbean in 14.1. The yield obtained from the harvest of treatment 1 and treatment 2 plots

were 60,150 kgs. and 61,905 kgs. respectively.

14.3 The peanut of Taiwan variety was cultivated in the same pattern as in 4.1 but the border rows surrounded the experimental plots were cassava, Rayong 1 variety. The first and the second treatments and the harvest yield of 130.4 kgs. and 193.4 kgs. respectively. The insect pests observed were cabgage loopers, cotton leaf worms and cotton boll worm. It was noticable that the second treatment (with cassava border rows) had a lower population of insect pests. The natural enemies found were Coccinellid beetles, larval parasitic wasps and spiders.

It can be concluded that the legume crops had a higher crops. This was probably because the field crops were the sources for natural enemy production that benefited the control.

B. Seminars and Training

1. There were a total of 6 seminars and training sessions on mass production of the nematodes ***N. carpocapse*** for controlling the bark eating caterpillar held in different regions of the country. The audience of the seminar were as follows :
   - 1.1 The officers from plant Protection Unit 4, Department of Agricultural Extension.
   - 1.2 The lecturers from the Department of Entomology, Faculty of Agriculture, Khon Kaen University.
   - 1.3 The participants of the workshop on "Modern Technology of Plant Protection" organized by the Plant Pathologists Association of Thailand.
   - 1.4 The participants of the seminar on "Fruit Crop Development", in Yala province.
   - 1.5 The participants of the conference on "Development of Longong Growing in the Southern provinces, Thailand., in Narathivat province.
   - 1.6 The officers of the Department of Agricultural Extension of the Southern part of Thailand.
2. Training of 100 Longan farmers in Lumphun and Chiang Mai provinces on the use of ***Anastatus*** sp., the Longan stink bug egg parasite, to control the Longan Stink Bug, one of the most important pests of Longan.

   There were also 2 large scale demonstration plots, each 90 rais, in Umong District and Pong-Chang Kuan District, Lumphun province. The work was in cooperation with the Plant Protection Unit in Chaing Mai, Department of Agricultural Extension. In this demonstration, it was shown that the expenditures on chemicals were reduced by some ten thousand baht. To other indirect gain was to reduce the risk of chemical contacts by farmers, workers and the Longan fruit consumers.
3. Production and distribution of NPV, approximatily 20 lt, to farmers for their use in controlling the Cotton Boll worm was completed.

C. Extension Activities (DOAE)

1. Seminar and Training
   - 1.1 Two special seminars on biological control in U.S. were held by the three - DOAE study tour staff in 1989 at Western and Southern Regional Plant Protection Offices. The experience gained and reprints collected on the tours were transferred to 50 plant protection officers. The technology was then applied and extended to farmers.
   - 1.2 Training of 650 local extension officers in 6 regions on biological control. These local extension officers transferred the new technology to farmers through training and visiting, demonstration fields and exhibitions.
2. Publications

   8,500 books on "The Natural Enemies of Fruit Crop Pests and Their Conservation Methods" were written and published to use as a guide for the project staff, Kaset Tambons and local leader farmers for field practices through out the country.

3. Demonstration Fields

Biological control demonstration fields by mean of conservation and augmentation were conducted on various economic crops in collaboration with 7,200 farmers on 58,425 rai in 32 provinces; there were :

1. Conservation of natural enemies (Predators)

Know-how on beneficial insects and conservation methods were transferred to farmers through demonstration fields. Farmers could understand the role of natural enemies in suppressing the population of pests as promoted by farm practices. Farmers obtain benefits from the enhanced population of natural enemies and the recognize these naturally occurring biological control agents as natural resources. This activity resulted in a reduction of insecticide use on rice, soybean and sugarcane as followings :

1.1 1,500 rice farmers practiced conservation methods and reduced insecticide use equivalent to 3.0 million baht.

1.2 1,500 soybean farmers practiced conservation methods and reduced insecticide use equivalent to 3.0 million baht.

1.3 2,100 sugarcane farmers practiced conservation methods and reduced insecticide use equivalent to 4.2 million baht.

2. Augmentation of natural enemies

The effective natural enemies were mass produced and released in demonstration fields of various economic crops : these were :

2.1 Use of ***Eocanthecona furcellata*** to control leaf and flower eating caterpillars in rambuton, tangerine and oil palm.

1.8 million predatory insects ***Eocanthecona furcellata*** were mass reared and released to control leaf and flower eating caterpillars in rambuton, tangerine and oil palm in the area of 300 rai per crop in 3 provinces. The rate of release was 2,000 predatory bugs per rai. The result of control was 70 - 80%. This activity reduced insecticide use of 180 farmers the equivalent of 450,000 baht.

2.2 Use of ***Metarhizium anisopliae*** to control ***Oryctes rhinoceros*** in coconut.

600 kilograms of the green muscardine - ***Metarhizium*** anisopliae var. major were propagated and used for rhinoceros beetle - ***Oryctes rhinoceros*** in coconut in the area of 800 rai in 4 provinces. The rate of using was 0.5 kg. per a composed pile (2+2+0.5) which used as a breeding site for rhinoceros beetle. The result of control was 80%. This activity reduced insecticide use of 160 farmers equivalent to 160,000 baht.

2.3 Use of ***Neoapletana corpocapsae*** to control Cossus sp. in langsat and longgong.

200 litres of parasitic nematode - ***Neoaplectana corpocapsae*** were produced and used for bark-eating caterpillar in langsat and longgong in the area of 200 rai in 2 provinces. The rate of using was 2,000 nematodes per 1 litre of water. The result of control was 85%. This activity could reduce insecticide use of 40 farmers equivalent to 600,000 baht.

2.4 Use of Anastatus sp. to control ***Tessaratoma papillosa*** in longan.

4 million egg parasite of longan stink bug - ***Anatatus*** sp. were mass reared and released to control longan stink bug - ***Tessaratoma papillosa*** in the area of 400 rai in 3 provinces. The rate of releasing was 10,000 wasps per rai. The result of control was 80%. This activity could reduce insecticide use of 80 farmers equivalent to 200,000 baht.

2.5 Use of ***Trichogramma confusum*** to control ***Chilo infuscatellus*** in sugarcane.

160 million egg parasite - ***Trichogramma confusum*** were mass reared and released to control sugarcane top borer - ***Chilo infuscatellus*** in the area of 1,000 rai in 2 provinces. The rate of release was 20,000 wasps per rai. The result of control was 90%. This activity could reduce insecticide use of 200 farmers equivalent to 400,000 baht.

2.6 Use of Nuclear Polyhedrosis Virus to control ***Heliothis armigera*** in cotton.

500 litres of Nuclear Polyhedrosis Virus were multiplied and used for cotton boll worm - ***Heliothis armigera*** in the area of 500 rai in 3 provinces. The

rate of using was 50 ml. per 20 litre of water. The result of control was 70%. This activity could reduce insecticide use of 100 farmers equivalent to 400,000 baht.

2.7 Use of ***Metarhizium anisopliae*** to control ***Patanga succincta*** in corn.

1,000 kilograms of ***Metarhizium anisopliae*** var. minor were multiplied and used for locust - ***Patanga succincta*** in corn in the area of 1,000 rai in one province. The rate of using was 1 kg. per rai which gave 80% control. This activity could reduce insecticide use of 200 farmers equivalent to 180,000 baht.

2.8 Use of ***Eocanthecona furcellata*** and ***Neoaplectana carpocapsae*** to control leaf eating and pod boring caterpillars in soybean.

1 million predatory bugs - ***Eocanthecona*** furcellata and 360 litre of parasitic nematods - ***Neoaplectana carpocapsae*** were multiplied and use against leaf eating and pod boring caterpillars in soybean in the area of 375 rai in 6 province. The rate of release were 1,000 predatory bugs per rai and 2,000 parasitic nematodes per 1 ml. of water respectively when the caterpillars reached 50% of ETL (Economic Treshold Level) which gave 90% control. This activity could reduce insecticide use of 195 farmers equivalent to 195,000 baht.

2.9 Use of ***Eocanthecona furcellata*** to control ***Achaea janata*** in Castor.

1.2 million predatory bugs were mass produced and released to control castor semi-100 per - ***Achaea janata*** in castor in the area of 600 rai in 2 provinces. The rate of release was 2,000 predatory bugs per rai which gave 90% control. This activities could reduce insecticide use of 120 farmers equivalent to 42,000 baht.

2.10 Use of Nuclear Polyhedrosis Virus and ***Neoaplectana Carpocapsae*** to control ***Spodoptera exigua, Spodoptera litura, Trichoplusia ni*** and ***Plutella xylostella*** in vegetables.

400 litres of NPV and 400 litres of ***N. carpocapsae*** were multiplied for leaf eating caterpillars in vegetables e.g. ***Spodoptera exigua, Spodoptera litura, Trichoplusia ni*** and ***Plutella xylostella*** in the area of 400 rai. The rate of using was 50 ml. per 20 litre of water and 2,000 nematodes per 1 ml. of water respectively. The result of control was 70% which could reduce insecticide use of 80 farmers equivalent to 3.15 million baht.

Conclusion :

1. 7,200 farmers accepted the new technology and were able to practice it themselves.
2. 11 target pest species were effectively regulated by biological control in the project area of 58,425 rai.
3. The insecticide application of 7,200 farmers was reduced by 16 million baht which resulted in an increase of farmers' income.
4. The project contributed to the conservation of the environmental balance.

8. Benefits and Recommendations :

A. Benefits

The results of the total of 14 activities on the uses of natural enemies such as predatory and parasitic insects, fungi, bacteria, nematodes and viri for controlling different important crop pests were most satisfactory to most farmers due to the direct benefits gained as follows :

1. The program was a very safe control method for users and product consumers because there is no toxic residues.

2. The bio-control solved insect resistance to chemicals problems because the biological control agents weakened the resistance of insect pests.

3. For crops grown for export, the bio-control supported and promoted the export for the crops had no chemical residues.

4. The program is a long life control measure because the beneficial organisms used multiply and reproduce themselves in the environment.

5. In some cases, such as the NPV. of the Cotton Boll Worm the farmers were taught to produce the virus from local infestations.

Project operations and results satisfactority achieved the project objectives and had a longer life than the proposed project duration. This was known after the farmers saw the success of the project and came to contact the Division of Entomology and Plant Protection Service Division in Bangkok to obtain more biological agents such as nematodes, NPV and egg parasites for farm use. This shows that the understanding of biological control technology in cropping systems has been well established and the success of the technology will be further extended to farmers on a larger scale by the officers of the Department of Agricultural Extension and Department of Agriculture.

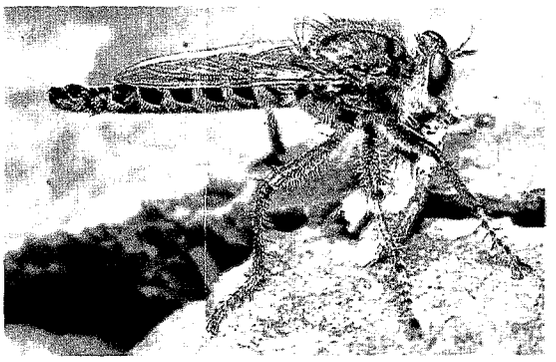
B. Recomendations

1. There should be a government institution responsible for an effective mass culture of the successful biological control agents or the existing DOAE program should be strengtened. The products should be certified for their quality, effectiveness and enough in quantity for a large scale use.

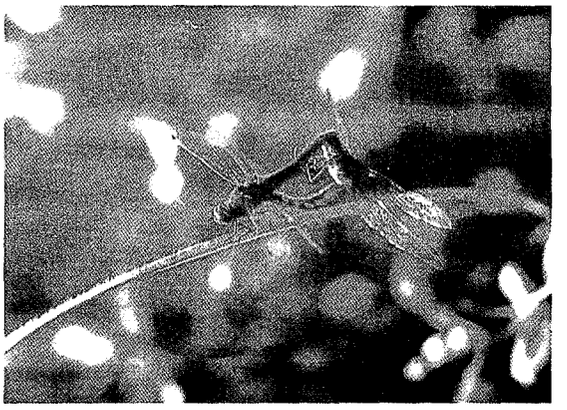
2. The work should be strenghtened through cooperation with the private chemical sole agencies to conduct an integrated pest management program to maintain the natural balance and to hinder the insect resistance problems.

The adult of *Chilomenes sexmaculatus*, the common predator in cotton field.

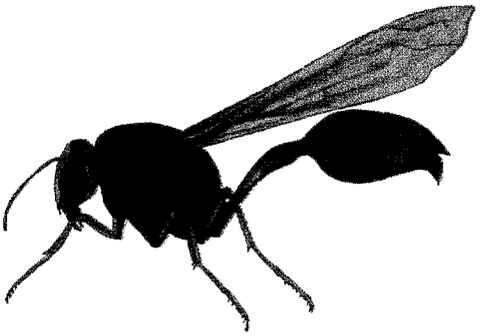
The predatory wasp is attacking cotton bollworm, *H. armigera*



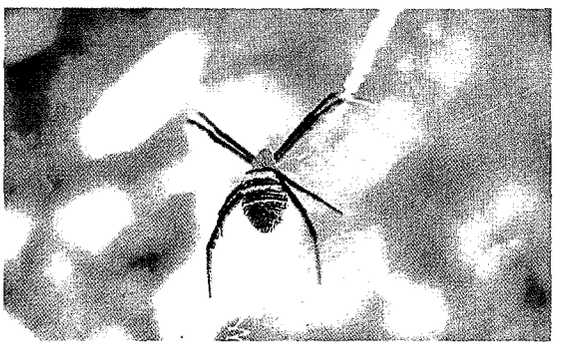
The soldier fly is the predator which attacks many moxths



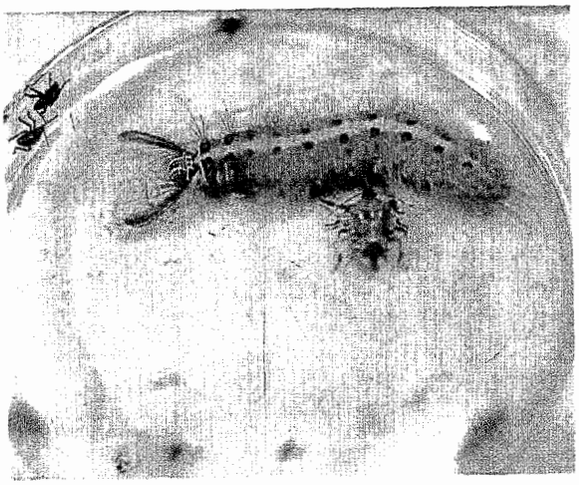
The dragon flies are predators attacking many insect pests



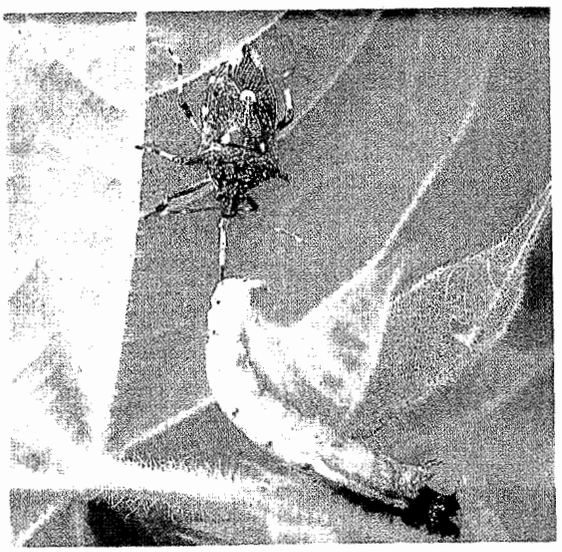
The Vespid wasp is the predator attacking many lepidopterous larvae



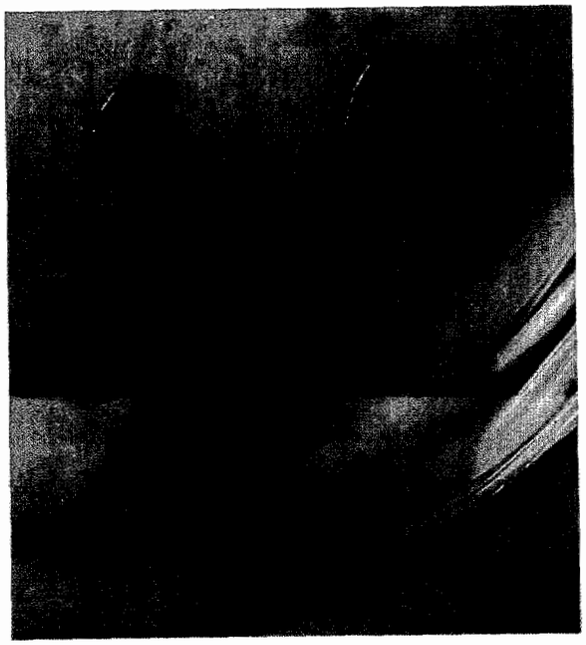
The spider is the important predator in paddy fields and in the orchards.



The stink bug, *Eocanthecona furcellata* is the predator which attacks many oil palm pests such as *Amathusia* sp.



The adult of predatory bug, *E. furcellata* is sucking body fluid from *Heliothis armigera* on cotton.



The assassin bug, *Sycanus collaris* is sucking the body fluid from *H. armigera.*

The egg clusters of assassin bug, *S. collaris*

1. Sub-Project Title : **Black Pepper Development for Export (031)**

2. Responsible Agency : Department of Agriculture

3. Life of Project : March 1988 - January 1991

4. Approved Budget :

Loan	US $	148,173	
Grant	US $	20,000	
Total	**US $**	**168,173**	

5. Actual Expenditures :

Loan	US $	126,395	
Grant	US $	18,979	
Total	**US $**	**145,374**	**or approximately 86% of approved budget**

6. Objectives :

6.1 To accelerate research work and develop black pepper varieties to find new technology for improving quality and increasing production.

6.2 To transfer advanced technology from international research to Thailand, known new technologies will be tested and adapted to Thai conditions.

6.3 To extend project results on suitable planting areas, planting materials to farmers and commercial operations for export.

7. Accomplishments :

7.1 Location of test sites :

Tests have been conducted under highland conditions (700 and 1,200 m. above sea level) and lowland conditions in the Northern part of Thailand. Vine pepper was used in the highlands and bush pepper in the lowlands. Two varieties of pepper; namely, Sarawak and Sri - Lanka were used in varietal trials.

It was found that growth of vine pepper under highland conditions was not successful. At Doi Mu Sur Horticulture Experiment Station most vine pepper showed virus disease symptoms. At Va - Vee Highland Experiment Station, growth rate was slow. Plant height was only half of that expected. It may be because of low temperatures in the winter season.

Growth rate of bush pepper at Pi-chit Horticulture Research Station was excellent; especially when 50% plastic net shade was used. Bush pepper at Nakorn-Panom Horticulture Experiment Station also showed good growth. At Thachai Horticulture Experiment Station only a Sri-Lanka variety showed good growth.

Breeding Study : New variety of pepper cannot get from abroad so the project does not implement this activity.

7.2 Fertilizer and water trial :

1. Fertilizer and watering trials on vine pepper at Trang Horticulture Experiment Station showed that about 20% of plants died from rootrot. In trials at Tung-pel Rubber Experiment Station the height of plants was good. Fertilizer and water was also applied.

2. Bush pepper trials at Trang Horticulture Experiment Station found that about 80% of plants (Sarawak variety) died from rootrot. Growth of the Sri-Lanka variety was healthier.

7.3 Disease control :

A test of black pepper management to control rootrot disease at Pong-rad Rubber Experiment Station is still underway.

Variety trials to find rootrot resistant varieties at Chumporn Horticulture Research Centre found that many plants of the Sarawak variety died from rootrot, about 60% of the vines of Sri-Lanka and Pa-leaion varieties died from rootrot. The surviving plants did well.

7.4 Intercropping system :

A test of vine pepper planted under Sa-tore trees at Nai-chong Rubber Experiment Station is still underway.

A test of Sri - Lanka bush pepper under Sa-tore trees at Tha-Lang Rubber Experiment Station is still underway. Bush pepper of Sarawak variety is smaller than Sri-Lanka variety.

7.5 Processing study :

Tests showed that green peppercorns should be soaked in boiling water for 5 minutes and then soaked briefly in cold water immediatly prior to canning with a preservative solution. The green peppercorns are placed hermatically sealed container and subjected to an elevated temperature for 10 minutes to destroy spoilage organisms. Three formulas of preservative solutions tested showed that 2% salt, 2% citric acid and sodium benzoate (1,000 ppm.) gave good results. As a result green peppercorns canned for 1 month still had good color and the preservative solution was not contaminated.

Vine pepper at Doi Mu Sur Horticulture Experiment Station

Fertilizer and watering trials on vine pepper at Trang Horticulture Experiment Station

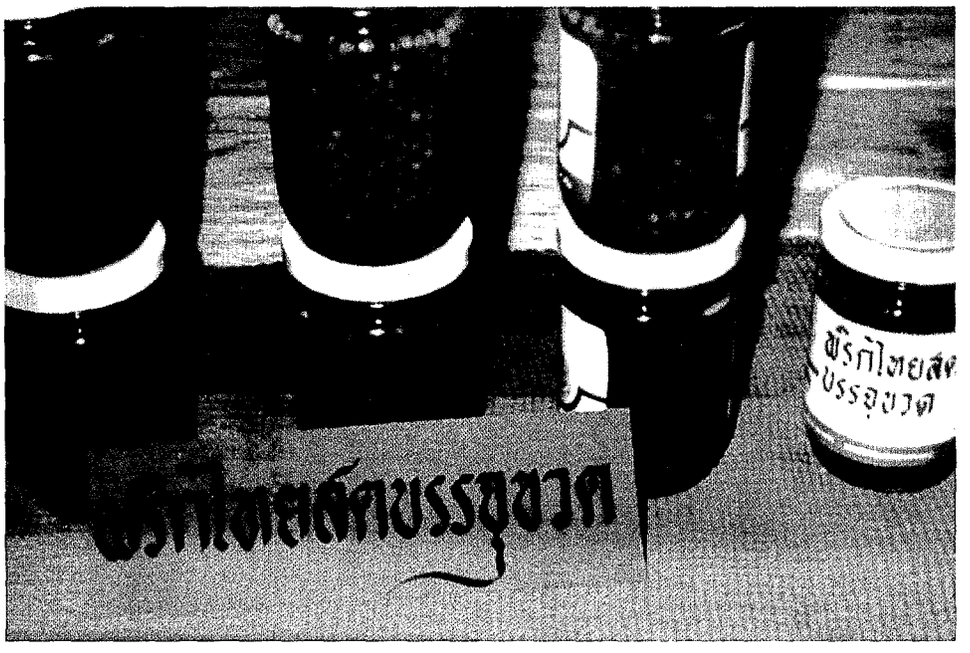
Fertilizer and watering trials on vine pepper at Tung–pel Rubber Experiment Station

Black pepper management to control root rot disease at Pong–rad Rubber Experiment Station

Vine pepper planted in Sa–tore trees at Nai–chong Rubber Experiment Station

Bush pepper planted under Sa–tore trees at Tha–lang Rubber Experiment Station

Weed control at Wang-tang Rubber Experiment Station



Green peppercorn processing by bottling, Thailand

1. Sub-Project Title : **Transfer of Feeding Buffaloes (033) (Agricultural waste Products as Buffalo Feed during the Dry Season in the Northeast of Thailand.)**

2. Responsible Agency : Department of Animal Science, Faculty of Agriculture, Khon Kaen University

3. Life of Project : March 1988 - March 1989

4. Approved Budget : **Total** (Loan) **US $ 27,487**

5. Actual Expenditures : **Total** (Loan) **US $ 27,166** **or approximately 99% of approved budget**

6. Summary of Problem and Objectives :

A. Problems :

Buffalo have played an important role in the Thai farming system for generations, serving as draught power and providing meat and other useful by-products. They also represent wealth to the farmer which can be passed on to children.

Herds of buffalo are usually small, averaging 2-5 head, and the number is closely influenced by area of crop land and available family labour. The total population of buffalo for the entire kingdom as reported by the National Statistics Office (1978) was 6.1 million for the year 1981. Most buffalo were raised purposely for draught power particularly the northeast region, which contains 65% of the buffalo population. Working time of water buffalo has been compiled by Konants et al. (1984), and showed the average working period to be 122 days/year and 5 hours/day. The responsibility of raising water buffalo rests with young school age children or the older family members. The pattern of herding these animals varies by seasons.

Several surveys conducted in villages in northeast Thailand including work by Rufener (1975) also revealed seasonal patterns of animal growth. Based on information from two villages, significant depressions of growth of working, nursing and young buffalo was lowest from December to April which coincided with availability of low-quality feedstuffs. It was also reported that buffalo parturition was seasonal, during October-March (Rufener 1975) and November-April (Thummasang 1985). Buffalo calf mortality rates varied from as low as 10% (Rufener 1975) and 12.5% (Yano 1985) to as high as 35% (Lohr and Bhannasiri, unpublished) especially below 6 months of age. It calves survived, however, they showed retarded growth. Possible causes of high calf mortality included malnutrition, parasites (Toxocara vitulorum and Strongyloides papillosus) and contagious diseases. However, the incidence of malnutrition would worsen the impact of parasites and diseases. An anonymous Thai report stated that apart from worm infection, another cause of calf mortality was insufficient milk supply by the dam. This is particularly the case with calves born during the dry season. Amount of feeds and their quality do not only affect growth rates but also affect the amount of milk produced during this critical nursing period. Draught power as in full operation from May to October when quality of feeds was critical for the first 120 days prior to the heavy work season for the animals. (Thai-German Project, 1986, unplubished data).

In general, farmers usually plant a second crop after rice such as cassava, sugar-cane or kenaf. By-products from these field crop can be used for feeding buffalo during the dry season. Most of farmers do not know how to apply the agricultural waste products for buffalo feed. If they know the appropriate way to feed buffalo by-products during dry-season, they would grow with strength and work with efficiency.

B. Objectives :

1. To study ways to solve nutritional feed scarcity for buffalo during the dry season.
2. To study strategies of feeding draft buffalo waste materials.
3. To improve draft efficiency by improved nutrition.
4. To improve growth performance of buffaloes by utilizing locally available crop residues.

5. To measure farmers' attitude to feeding new materials (technology acceptance).

7. Accomplishments :

7.1 General information of village

The research was carried out at Ban Kham Pia, Thum Bon Ban Had, Amphur Ban Pai, Khon Kaen, which is about 28 km from Khon Kaen University. This village is divided into 2 zones, the member of families in the first zone is 220 and 100 in the other. The area is 7,065 rai in which 6,565 rai for crop cultivation and 500 rai for residences; the population earned 10,000 - 15,000 baht/ year/houseshold.

7.2 Fifty three farmers, who have had draft buffalo were participated in this research and 89 draft buffalo were taken in this research project, and allotted into 5 dietary management groups as follows :

Group 1. Traditional buffalo raising
Group 2. Same as group 1 plus deworming
Group 3. Same as group 1 plus supplemental dried cassava leaf (DCL) 500 g/d
Group 4. Same as group 1 plus urea-treated rice straw (UTS) 5 kg/d
Group 5. Same as group 1 plus supplemental DCL 500 g/d and UTS 5 kg/d

7.3 Daily feeding, feeds and data collection of buffalo, monthly liveweigh, rumen fluid, blood sample and draft performance were measured throughout the period of work. Samples of feeds and other samples were chemically analyzed in the laboratory.

7.4 Results and Discussion

The chemical composition of feedstuffs – DCL has high crude protein content (25.9%) and low hydrocyanic acid content when sun-dried for 1-2 days (Wanapat et al., 1989). Crude protein content of rice straw was increased from 2.9% to 5.7% by ensiling rice straw with 5% urea for 10-14 days. The fiber content of RS and UTS were normal ranges.

Rumen fluids were sampled monthly during the dry season in the morning and in the evening and measured for pH immediately and later for ammonia-nitrogen (NH3-N). It was found that pH of rumen fluid were normal, (6.8-7.1). Ammonia-nitrogen productions in the rumen of animals which supplemented with DCL and/or UTS were higher than in the rumen of animals in group 1 and 2 both in the mornings and the evenings.

Liveweight changes of draft buffaloes indicated that body weight of draft buffaloes in all groups could be maintained in the dry period (Mar-May) and were enhanced in the rain season Although, liveweight changes of group 1 and 2 were not significant when compared to supplemented groups, buffaloes in supplemented groups could increase body weight significantly both in the dry season and the rainy season.

The interaction between deworming and feeding regime did not show any effects on body condition, however, the results on female draft buffalo were greater than in the males.

Draft capacity of buffalo, although draft efficiency was not significantly different among groups, liveweight change in supplemented animals were not affected even when early working period occured and increased throughout the year.

8. Benefits and Recommendations :

1. Simple feeding management using dried cassava leaves (DCL) and urea-treated rice straw can be easily practiced by farmers.

2. Farmers were able to secure dry season feeding from locally available crop residues for draft buffalo in appropriate ways.

3. Ruminal nutritional levels in draft buffalo during the dry season were increased, hence better buffalo conditioning resulted.

4. Feeding buffalo with minimal amounts of good feeds to increase rumen NH3-N and volatile fatty acids improved growth performance of the dam and calves, draft ability and increased sale value of buffalo at the end of working season.

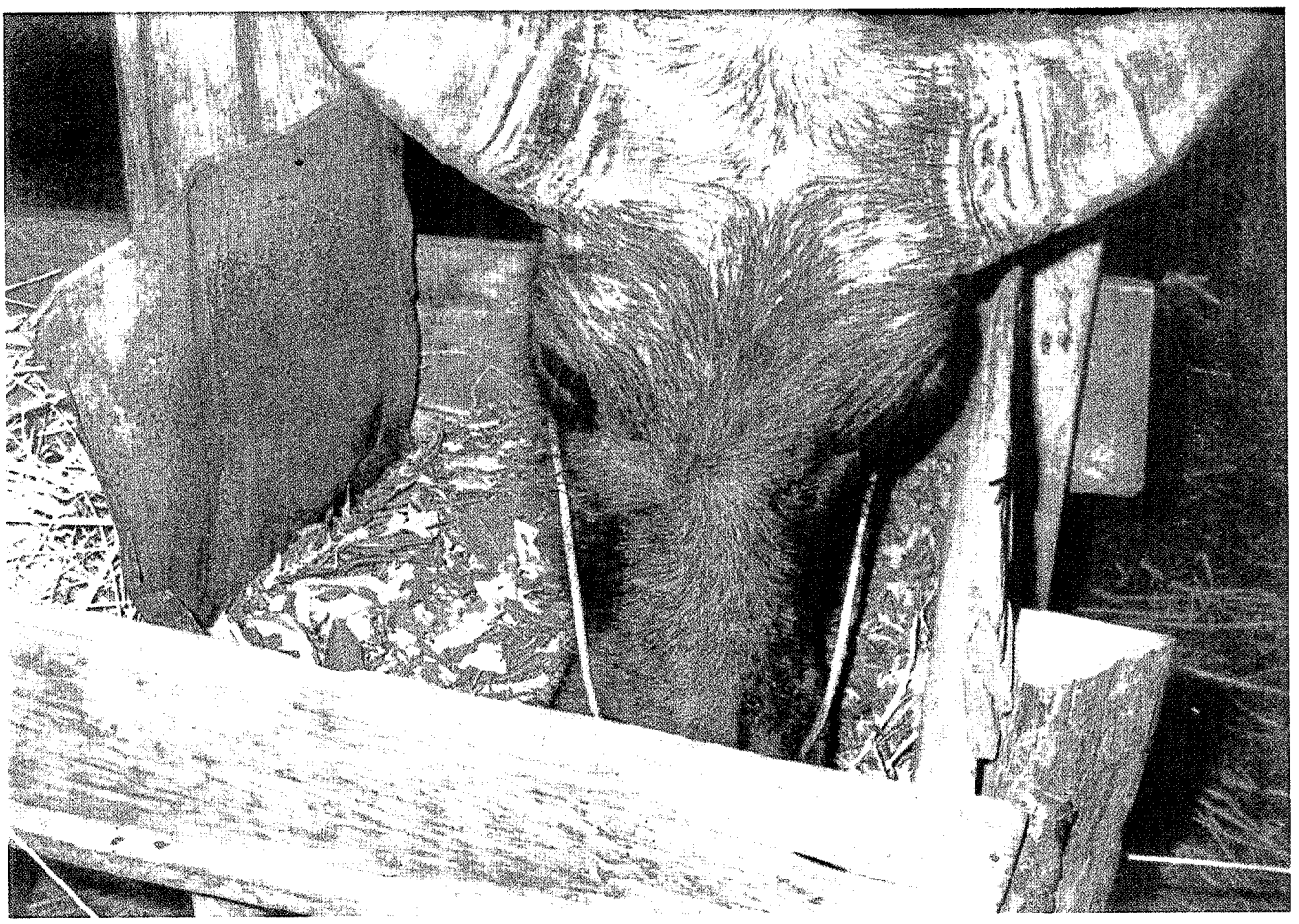
5. Improved nutritional status of draft buffalo may also have affected on subsequent reproductive performance and efficiency.

6. Feeding of draft buffalo with good quality feeds during the dry season is highly recom-

mended to practice.

7. Further training courses of feeding draft buffalo based on cassava leaves and/or urea-treated rice straw are highly recommended for farmers particularly in the northeast by collaborating with responsible government organizations such as the Department of Livestock Development (DCL) and the Department of Agricultural Extension as well as non-governmental organizations (NGO).

Urea–treated rice straw process for Supplemental feed



Dry cassava leaf supplemental feed

1. Sub-Project Title : **Technology Transfer and Development Center for Phycocolloids. (034)**

2. Implementing Agency : Faculty of Science, Srinakarinwirot University, Prasanmit.

3. Life of project : 1989 - Jan. 1991

4. Approved Budget :

Loan	US $	201,117	
Grant	US $	20,124	
Total	**US $**	**221,241**	

5. Actual Expenditures :

Loan	US $	188,124	
Grant	US $	17,841	
Total	**US $**	**205,965**	**or approximately 93% of approved budget.**

6. Project Objectives :

6.1 To establish a pilot-plant for testing seaweed extraction processes to be used on an industrial scale.

6.2 To analyze and identify various phycocolloids processed from economically valuable seaweed found along the coastal area of Thailand.

6.3 To study and develop commercial processes suitable for the production of different phycocolloids at the pilot-plant level.

6.4 To train and transfer the knowledge about the phycocolloids produced from seaweed to those interested in industrial scale investment.

7. The Expected Outcomes of the Project :

The pilot-plant and the Center for Technology Transfer in Phycocolloid Processing has been established. This center concentrates on research and development of phycocolloid processing for industry. The success of the Center will be when the import of phycocolloids produced from seaweed is decreased and the export of the raw materials and finished products of seaweed processing is increased.

8. Technical Activities :

8.1 A workshop entitled : "Value-added Products from Seaweed Processing" was held on July 26-27, 1990. Thirty participants from the private sector and government offices were involved. The private sector such as Charoen Pokphand Co. and World Aqua Culture Co. have expressed high interest in seaweed production. We have assisted them in the production of ***Gracilaria spp.*** in the drainage canals of their shrimp farms. This also helps decrease pollutants on the shrimp farms.

8.2 Technology transfer of seaweed production to serve as a raw material for the agar industry was conducted in Songkhla. The research team travelled to the villages in Koh Yo, Songkhla, to provide technical assistance to the seaweed farmers. The local fishermen have used the line-insertion technique to produce agar-bearing seaweed using 60-80 lines per rai. The investment cost is approximately 1,000 baht per rai. The seaweed is harvested, sun-dried, and sold. The additional family income generated from seaweed farming is 800-1,000 baht per month. The harvest season is from April to September. Presently, seaweed farming has been firmly established as an additional vocation for fisherman in Koh Yo, Songkhla. The seaweed is used for local consumption as food, for agar processing, and export.

8.3 The research team has transferred the agar-bearing seaweed grown in Songkhla to test the possibility of production in the brackish-water ponds owned by a private company in Ban Pae,

Rayong. Within 6 months it was found that the seaweed had increased from 1 kg. to 500-700 kgs. per a 4-rai pond. It was harvested in July-September 1990. The owner of the pond is a former participant in the workshop arranged at Srinakharinwirot University in 1989 and has been working closely with the research team ever since. She cooperates fully in the study of pond culture of agar-bearing seaweeds in Rayong coastal area. Furthermore, she has developed a special food product from seaweed which she sells to tourists. With her success, agar-beaing seaweed has become a new vegetable in the area with high economic value.

The research team has distributed the information about seaweed production to other shrimp pond owners along the east coast. The team, together with the Center for Fishery Development in Eastern Thailand at Ban Pae, has brought the seaweed from the pond culture to feed abalone. The results are promising and reflect the successful cooperation between the private sector, the government offices and the research team.

8.4 The research team has transferred the technology and knowledge in seaweed processing by distributing publications and information to the following :

- College of Engineering, Central Phillippines University
- University of Mawlamyine, Union of Myanmar
- Fisheries Division, Solomon Islands
- Private Companies in Brazil and Chile
- Cauraros Co., Malaysia

8.5 The center has provided a custom service in agar extraction and analyses for the public, locally and internationally. The seaweed is sent from the private sector in Koh Samui, Thailand; the Phillippines, Indonesia, and Solomon Islands. The data they receive is used to develop plans for a local agar industry.

8.6 The project director, Ms. Suwalee Chandrkrachang, lectured on seaweed processing suitable to local industry at the international seaweed symposium, Bay of Bengal Program, (October 23-27, 1989) at Songkhla. Approximately 200 participants came from various countries in the Asia-Pacific Region.

The research team was invited to advise the Vietnamese government on the technology of seaweed processing under an FAO/UNDP project December 1989 - January 1990.

The Center provided training in the technology of seaweed processing and production to 5 Vietnamese as requested by UNDP and DTEC in October-November 1990.

8.7 The research team developed the technology of agar purification using chitin/chitosan from shrimp shells. This was thru a combination of the use of products from shrimp shell waste with the seaweed processing and the cooperation between the projects ATT 034 and ATT 043. The purified agar was approved by a foreign corporation which said that it has high quality suitable for biotechnology applications. Presently, the Center has contacted the private sector to assess the possibility of marketing the product.

9. Project Summary :

With the constant and continuous work of the research team with the support of ATT 034, the following have been achieved :

9.1 Presently the people in Southern Thailand, the private sector and the local government offices have come to realize the importance of seaweed. Seaweed production and marketing has increased significantly and has become a new business. This is a direct result of the technology transfer and the provision of markets by the research team.

9.2 Srinakharinwirot University and the Development Center for Phycocolloids is now firmly establishied. The Center has been legally approved and is well known internationally as an organization which can develop its own technology from seaweed and transfer it to other Asia-Pacific and developing countries. The Center will continue its mission as a technology transfer and information service unit in seaweed processing. It will provide preliminary studies of phycocolloid extraction and quality analysis to the public and concentrate on the R&D of other phycocolloid products in the future.

10. The Activities after Project Completion :

10.1 Transfer the technology of carrageenan extraction from ***Euchema*** as requested by the private sector in Thailand and Indonesia using the pilot plant received from ATT 034.

10.2 Arrange a workshop on seaweed production and processing as requested by the FAO. The participants will be from Asia-Pacific countries. The workshop is scheduled for November 1991. The equipment and the pilot-plant received from ATT 034 will be used in the workshop.

1. Sub-Project Title : **Quality Inspection for Agricultural Products for Export (035)**

2. Responsible Agency : Agricultural Chemistry Division, Department of Agriculture

3. Life of Project : 1989-1990

4. Approved Budget :

Loan	US $	159,334	
Grant	US $	54,264	
Total	**US $**	**213,598**	

5. Actual Expenditures :

Loan	US $	130,344	
Grant	US $	47,195	
Total	**US $**	**177,539**	**or approximately 84% of approved budget**

6. Summary of Problems and Objectives :

A. Problems :

Thai export of food and agricultural processed products are constrained because of their variable qualities which often do not meet international standards such as Codex Alimentarius Standards. Some importing countries use automatic detention measures for Thai products. Agricultural Chemistry Division, Department of Agriculture is concerned with solving export problems, especially those concerning quality and international quality standard requirements. There is a need for a system of quality analysis and certification, including.

1. general quality inspection of processing plants.
2. quality inspection and analysis of products to ensure international standards are met.
3. analysis for mycotoxins to protect local consumers.

The data analysis would be beneficial for :–

1. improvement of quality of food and agricultural products for export.
2. domestic quality standards provision.
3. establishment of an analysis and certification system for food and agricultural products for export.

This project proposal for assistance under the ATT was to support a government project entitled "Quality Inspection for Agricultural Products for Export". (A Cabinet decision made on 5 February 1985 approved the National Export Program proposed by the Office of the National Economic and Social Development Board).

B. Objectives :

To promote the export of food and agricultural products by :

1. improving quality of agricultural products for export.
2. providing data concerning quality control and inspection procedures to related off shore and domestic organizations and private sector.
3. providing technical data to related government agencies to permit both local and international standards to be met.
4. establishing a system for quality analysis and certification of food and agricultural products for export.

7. Accomplishments :

7.1 Analysis

1. Analyze for the issue of Export Inspection and Analysis Certificate - Approved for Export especially the canned food (canned fruits and vegetables). Inspectors inspect the factories and sampling the products from the lots to analyze for the food quality 68 samples 298 itmes.

2. Analyze the quality and certification of food and agricultural products for export. The item of determination is depended on Regulations and the Laws about imported products which enforced and promulgated by the Agency of these countries' government. (Export Standard). 469 samples 2,762 itmes.

- Sanitary certificate
- Heavy metal certificate
- Mycotoxin certificate
- Analysis certificate

3. Analyze the samples of food and agricultural products both in general quality and international quality standards to protect the consumer's health and safety such as the toxic substances by toxic microorganism as ***Clostridium botulinum.*** Furthermore we analyzed about Mycotoxins (such as Aflatoxins) Heavy Metals, Food Additives, Food value, Filth and Extraneous materials and etc. 2,765 samples 12,018 items.

4. Analyze canned pineapple in a joint project between Agricultural Chemistry Division and Thai Industrial Standards Institute to solve the problem of tin content in canned pineapple. 348 samples, 2,840 items.

7.2 Inspection

1. Inspection of the manufacturers who produce canned fruit and vegetables. The reguirements concern environment, sanitary conditions and production processes and quality control. Inspectors sample the products from the entire lot for analysis for food quality. 31 factories, 53 items.

2. Provide services of analysis and technical knowledge to the factories, especially in Low Acid Canned Food. Inspectors give their advice which is based on the inspection and scientific data approved for safety and effectiveness to improve the Quality Conrol of the manufacturer and his acceptance of the requirements of the law. 84 factories, 102 items.

7.3 Technical Transfer

Three seminars, one workshop, five exhibitions were conducted for the private sector. Brochures, documents, explanations and guidance to visitors was accomplished.

7.4 Training Activities

The staff of the project have been trained in Packaged Food Analysis, Mycotoxin and Food Additive Analysis including study tours in Quality Assurance at the Food and Drug Administration.

The participants obtained knowledge and new technologies of analysis from USFDA and University laboratories in the USA and these have been adapted to improve analysis and research in quality of food and agricultural products for export in Thailand.

8. Benefits :

The Quality Inspection for Agricultural Products for Export project has rendered services to the private sector according to the policy given by the Ministry of Agriculture and Cooperatives, including technology transfer, the benefits of which are listed below :

1. Assist in the decrease of international trade balance deficit because certification results in the decrease of detention and increase in foreign exchanges.

2. Assists Thai export commodities to be deemed reliable in foreign markets after being certified by CEICAP

3. The benefits of Memoranda of Understanding (MOU) with other countries are far beyond assessment. MOU's mean that exported commodities certified by Center of Export Inspection and Certification for Agricultural Products (CEICAP) can enter the USA, Canada, Sweden and Finland by waiving of inspection or less checking at the ports of entry. Therefore, expenses for rejection and loss of foreign exchange earnings by Thailand would decrease, and also a better image of Thai commodities is gained.

4. Prevent unfair or fake businesses from exporting.

5. Assist in the increase of farm income while ensuring manufacture of acceptable quality products.

9. Suggestions or Recommendations :

Even though the Project has achieved considerable, there are some problems requiring resolution. Some importing countries are demanding more of CEICAP but the Project has been active for only a short time. CEICAP requires added assistance such as :

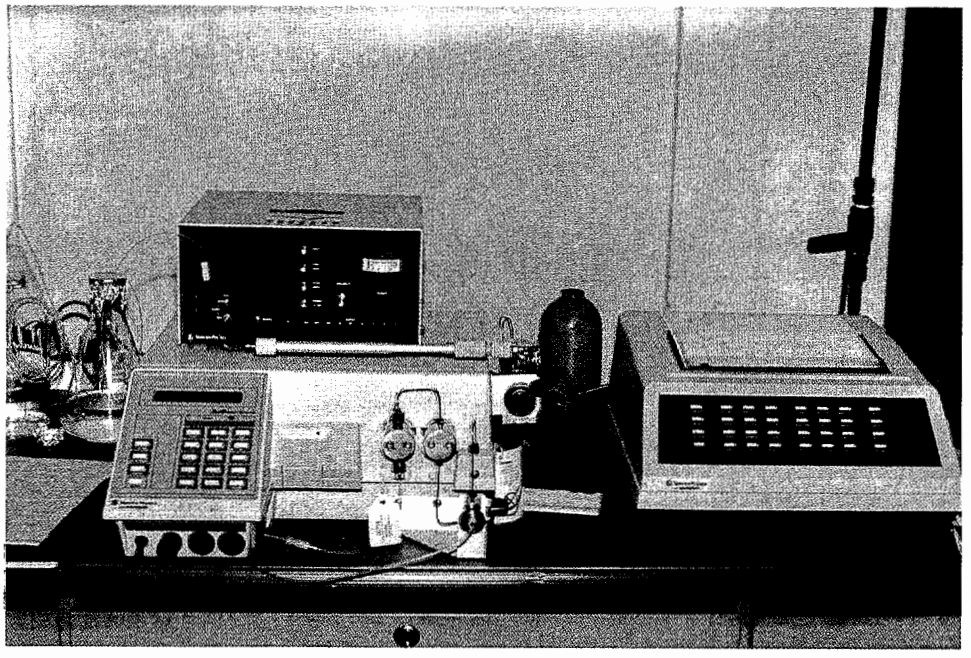
1. Training, Observation tours, fellowships on some specific subjects, i.e. Nutrition, Microbiology, Filth, Mycotoxins, Food Additives, and Food Packaging.

2. Expert consultancies in analytical examination of Vitamins and Amino Acids, Can Seams and Physical and Sensational Inspection (Organoleptic test).

3. Granting funds for the visits of foreign officials to inspect agricultural products exported to those countries, both for inspection and analytical examination, for the purpose of waiving or decreasing the inspection procedures on the arrival of the Thai commodities at the port of entry to avoid the detention or rejection of such commodities.

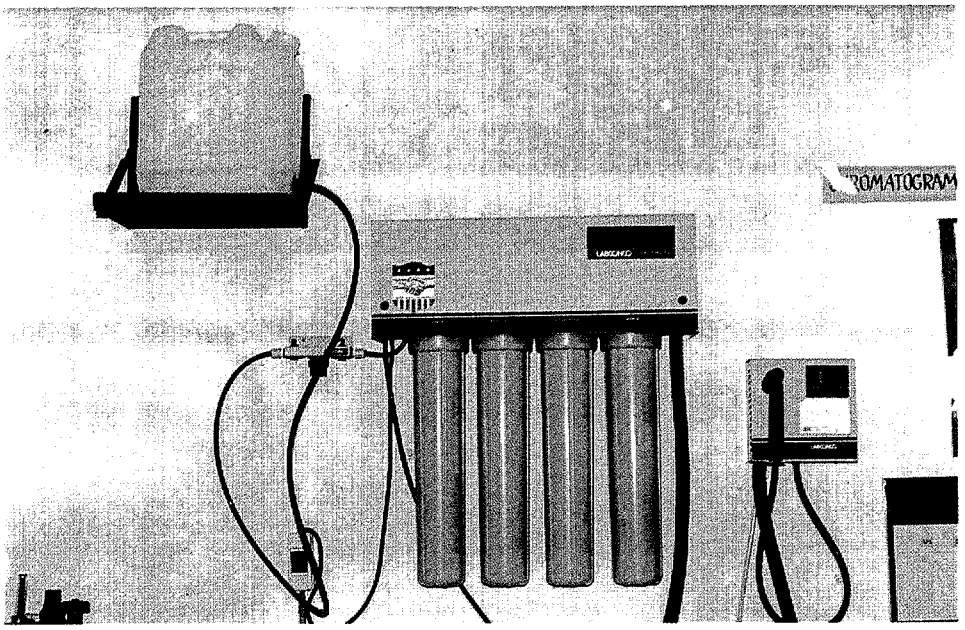
4. Production cost of video tapes for publicity for the Project in the importing countries and for technology transfer of good manufacturing practices to the Thai private sector.

If the Project could receive the aforementioned support, it would therefore be able to carry on operations without disruptions.

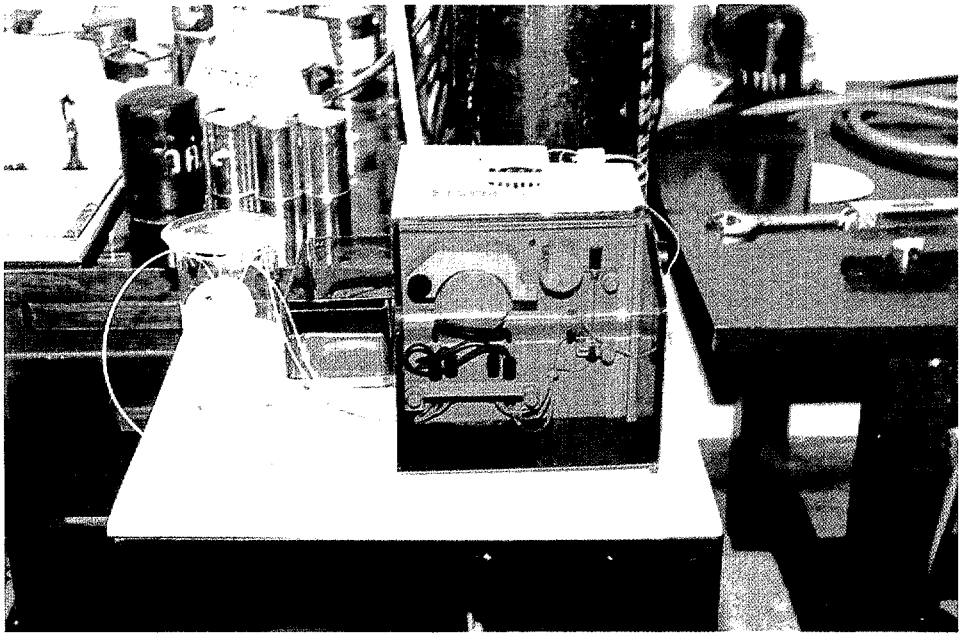


(High Performance Liquid Chromatograph–HPLC) for analyse Aflatoxin, Zearalenone, Ochratoxin and Patulin.

Graphite Furnace Atomizer for analyses Cadmium, Lead, Cromium, etc.



Demineralizer for chemical laboratory use.



Hydride Vapor Generator for analyse Arsenic, Mercury Selenium, Antimony and Tin.

Seminar on Certification of Can Food Products for export at Methavalai Hotel on September 28, 1989.

Dr. R.A. Ralston, ATT, long-term Adviser and USAID Thailand officers visited the Project's Laboratories on August 7, 1990.

Report on Quality Inspection for Agricultural Products for Export
(October 1, 1988 - September 30, 1990)

No.	Activities	List of Analysis	To Whom	No. of Samples	No. of Items
1.	Analyze for Export Inspection and Analysis Certificate - Approved for Export	Export Inspection and Analysis Certificate	Canned food factories	68	298
2.	Analyze and certificate	Sanitary certificate Heavy metal certificate Mycotoxin certificate Analysis certificate	Private sector	469	2,762
3.	Analyze for quality of raw materials and finished product such as rice and rice products corn, mung bean, fruit and vegetables	1. Microorganism such as Yeast, ***E. coli*** 2. Mycotoxin such as Aflatoxins B_1, B_2 3. Heavy metals such as tin, Lead, Arsenic etc. 4. Food value such as Moisture, Protein Sugar etc. 5. Food Additives such as sulfur dioxide etc. 6. Filth Determination such as Insect Larva, Hairs etc.	Private sector Government service	2,765	12,018
4.	Analyze canned pineapple	Tin, Copper, Sugar, Acid, Brix, pH, Taste, Colour, Odour, Vacuum, Head space, Drain weight, Net weight, Nitrate	Joint project between TIST and Agricultural Chemistry Division	348	2,840
5.	Inspection the canned food factories for export	1. Inspection of canned fruit and vegetable factories is based on environment, sanitary condition production process and sampling the products is also done for quality standard	Canned fruit and vegetable factories	31 factories	53 tiems
		2. Provide the services on analysis and technical knowledge to the owner or managers of the factories especially in Low - Acid Canned Food	Canned food factories	84 factories	102 times

Quality Inspection for Agricultural Products for Export
Technical Transfer (October 1, 1988 - September 30, 1990)

Activities	Dates	Places	Participants	Number	Objectives
1. Seminar on Export Inspection and Certification System for Canned Food	July 20, 1989	Chiengmai Phucome Hotel, Chiengmai	Canned food factories exporter Government services	27	Information of the Project, Technical Transfer, Exchange Idia
2. Seminar on Export Inspection and Certification System for Canned Food	July 27, 1989	Seaview Resort Hotel, Chonburi	Canned food factories/exporter Government services	48	Information of the Project, Technical Transfer, Exchange Idia
3. Seminar on Export Inspection and Certification System for Canned Food	September 28, 1989	Methavalai Hotel Phetchburi	Canned food factories/exporter Government services	63	Information of the Project, Technical Transfer, Exchange Idia
4. Workshop on Development of the Canned Food Processing for Export	December 22, 1989	Central Plaza Hotel Bangkok	Canned food factories/exporter Government services	93	Technical transfer Exchange Idia, Solve Problems and Constraints
5. Exibitions	July 20, 1989 July 27, 1989 September 28, 1989 October 14-16 1989 December 22, 1989	Chiengmai Phucome Hotel Seaview Resort Hotel Methavalai Hotel Central Plaza Department Store Central Plaza Hotel	General	5 Times	Information of the project
6. Distributed the brochures, documents explanation, and guidance	October 1, 1988 September 30, 1990	Agricultural Chemistry Division	Director - General of UNDP, Director of USFDA, Journalist from Asia and Pacific Region, Japanese officials from the Ministry of Japanese Foreign Affair, Japanese Food Control Officials, JETRO The Indonesian Parliamentary Delegation, The Canadian Delegation; The USAID Officers and the expert of the ATT Project, An Australian Inspector; Director General from the Health Protection Branch, Canada; Commissioner of US. International Trade Commission; Experts from France, FAO USFDA and UNDP	23/47	Information of the Project, Coordination with Oversea Agencies related, Contact in Agreement or MOU and Technical assistance

1. Sub-Project Title : **Development and Extension of Cocoa as an Intercrop of Coconut (036)**

2. Responsible Agency : Department of Agriculture and Department of Agricultural Extension

3. Life of Project : 2 Years (1989-1990) (DOA was extended to June 1991)

4. Implementation Sites : Chumporn, Suratthani, Nakhon Srithammarat, Krabi

5. Approved Budget :

Loan	US $	236,596	
Grant	US $	29,563	
Total	**US $**	**266,159**	

6. Actual Expenditures :

Loan	US $	201,453	
Grant	US $	7,208	
Total	**US $**	**208,661**	**or approximately 78% of approved budget**

7. Sub-Project Objectives :

7.1 Varietal Improvement, propagation, and seedling production for farmers including technology transfer to improve quantity and quality product.

7.2 Extend cocoa as an economic crop in Thailand for export and for import substitution.

7.3 To increase rural industry and labour use.

8. Accomplishments :

A. DOA Accomplishments

1. Procurement

1.1 Civil constructions

The six building units: 1 fermentation plant, 3 glass houses, 1 plant preparation and 1 concrete water tank have been completed after approved of USAID and will be finished in June 1991. (Appendix IV)

1.2 Scientific equipment

The scientific equipment has been purchased except for the Pascal triple rollor mill and compound microscope which are underway. (Appendix V)

2. Technical Activities

2.1 Breeding and Seed Production

– Cocoa budwood has been arranged for delivery in March 1991. (Appendix VI)

– 21,940 cocoa hybrid pods or 658,200 seeds of IPa 7 × Na 32, UIT 1 × Na 32 and Na 33 × UIT 1 have been delivered to DOAE for use under the ATT project. (Appendix VII)

2.2 Soil Science

The research has not yet been start because three experimental buildings are being constructed.

2.3 Post - harvest and processing

The results of comparison of sun drying, indirect hot air drying and solar assisted drying of cocoa beans is shown in Appendix I.

2.4 Entomology and Zoology

Three research projects into the biology of the Mosquito bug (Helopeltis.); the effectiveness of insecticides on the Mosquito bug, and study on vertebrate pests and damage assessment in cocoa have been reported, (Appendix II)

2.5 Pathology

The results of study on varietal reaction of 15 hybrids of ***theobroma cacao*** L. to

vascular streak dieback, study on cocoa pod rot and study on cocoa leaf spot are shown in Appendix III.

B. DOAE Accomplishments

1. Cocoa stock production

As targeted, 600,000 cocoa seedlings were produced from 20,000 foundation seeds brought from Chumporn Horticultural Research Centre and Trang Horticultural Research Centre, DOA, of which 10,000 seeds were propagated to 300,000 plants at Krabi Horticultural Crops Propagaion and Promotion Centre and 10,000 seeds were propagated to the same amount at Surat Thani Horticultural Crops Propagation and Promotion Centre.

2. Nursery construction and facilities

Two temporary nurseries (8 × 24 metres), one at Surat Thani Centre and another at Krabi Centre were constructed with five sets of smog sprayers each since May and June 1990, respectively.

3. Procurement of cocoa seed dryers

Four sets of cocoa seed dryers were purchased for cocoa producers to use at Chumporn, Surat Thani, Nakhon Srithammarat and Krabi.

4. Extension plots

4,000 rai of cocoa extension plots were installed in Chumporn, Surat Thani, Nakhon Srithammarat and Krabi (1,000 rai each) and 650 farmers participated in the project.

5. Study-tour to Malaysia and Indonesia

Eight officers from DOA and DOAE made a study-tour to Malaysia and Indonesia during November 5-16, 1989.

9. Benefits and Recommendations :

A. Benefits

The value of the project for the improvement of cocoa research and production have been recognised by government organizations, the private sector and farmers.

At least 5,500 rai of planting per year will be supported by Department of Agriculture. It is estimated that the production of 520 tons of dry cocoa bean will be obtained in each year after the trees start to bear.

In addition to planting material, research findings will be of great benefit to farmers and private sectors concerned with cocoa culture.

There are 4,000 rai of cocoa plantation and 650 farm families who gain direct benefits from the project. From 1993 onwards, about 520 metric tons of cocoa will be produced, valued about 12 million baht per year. Each farm family will gain their average income of about 15,000 baht per year.

B. Recommendations

There were some constraints on the purchase of scientific equipment eg. insufficient budget and the conditions of purchase in addition the regulations for oversea study tour should be modified.

Appendix 1
Result of Post - harvest and Processing Research

The result of comparison of sun drying, indirect hot air drying, and solar assisted drying of cocoa beans shows the dry beans obtained from indirect hot air dyring method are of best quality, high chocolate flavor and low FFA (0.0033). It took 46 hours for the drying process. Simultaneously, the dry beans obtained from solar assistend drying and sun drying could not produce chocolate flavor and contained high FFA (1,1224 and 15,515 respectively) and took longer to dry; 6 and 8 days, respectively.

Appendix II
Results of Entomology and Zoology Researches

1. Study on the Biology of Mosquito Bug (***Helopeltis*** sp.. Miridae) is a major pest of cocoa. The larvae and adults feed on young cocoa leaves and pods. The egg stage take 10 - 12 days. The larvae have five stages 3, 2, 2, 2, and 2 days respectively. Outbreaks of Mosquito bug occur usually in rainy season.

2. The Effectiveness of Insecticides on the Mosquito bug.
   Highly effective insecticides are carbaryl, endosulfan and carbofuran etc.

3. Study on Vertebrate Pests and Damage Assessment in Cocoa.
   Mostly rodents attach cocoa pods. There are squirrel (***Callosciuius finlavsoni*** and ***Callosciuius*** caniceps, rat (***Rattus rattus*** L.) and civet cat (***Viveus*** sp.). The damage of cocoa pods varies with different locations.

Location	**% Damage/month**
CHRC	15.72
Samutsongkram province	22.15
Amphoe Pathiu (Chumphon province)	20.10

Appendix III
Results of Pathology Research

1. Study on Varietal Reaction of 15 Hybrids of ***Theobroma cacao*** L. to Vascular Streak Dieback.

The disease caused by ***Oncobacidium theobromae*** two hybrids are highly resistant. The study results of the disease on 15 hybrid cocoas follows:

Variety	% damage
1. Sca 6 × Sca 6	0
2. UIT 1 × Na 33	0
3. Pa 7 × Na 32	1.04
4. Pa 35 × Na 32	2.08
5. ICS 60 × Sca 6	2.08
6. UIT 2 × Sca 6	3.10
7. Na 33 × UIT 1	3.12
8. UIT 1 × Sca 6	5.21
9. Upper Amazon	6.25
10. Na 33 × ICS 60	6.25
11. Na 33 × Sca 7	7.29
12. I 466 × Sca 6	7.29
13. UIT 1 × Na 32	7.29
14. UA 13 × UIT 1	7.29
15. Pa 7 × Na 33	8.33

2. Study on Cocoa Pod Rot the study showed that the cocoa pod rot caused by fungus ***Phytophthora*** sp. only was not associated with wounds, compared to rot following insect or rodent damage.
3. ***Study on Cocoa Leaf Spot:*** This study showed the disease did not affect cocoa nut yield.
4. Study on Relation between Environment and Distribution of Cocoa Pod Rot Disease: This research is being carried on.

Appendix IV

The 4 Building materials :

1. Fermentation Plant	1 unit
2. Glass House	3 unit
3. Plant Preparation Unit	1 unit
4. Concrete Water Tank	1 unit

Appendix V

The 18 scientific equipments purchased

1. Soxhlet apparaters	1 unit
2. Pascal motor mill	1 unit
3. Plant grinder	1 unit
4. Pressure pump	2 units
5. Deionizer filter	1 unit
6. Stainless steel water tank	1 unit
7. Water pump	2 units
8. Environment chamber	3 units
9. Potter's spray tower	1 unit
10. Thermohygrograph	2 units
11. Vacuum insect collector	2 units
12. Incubator	1 unit
13. Hydraulic press	1 unit
14. Oven (max 300°C)	2 units
15. Irrigation pipe (poly ethylene)	1 set
16. Hot plate	2 units
17. Light intensity metre	2 units
18. Fumigation chamber	1 unit

The 2 remaining scientific equipments being purchased

1. Pascal triple rollor mill	1 unit
2. Compound microscope	1 unit

Appendix VI
A List of 30 Cocoa Clones

1. AMAZ 3-2
2. AMAZ 15-15
3. BE 3
4. BE 10
5. CC 11 (Puerto Rico)
6. EQX 3380-1
7. IMC 61
8. IMC 67
9. ICS 16
10. ICS 100
11. LAFI 7
12. LCT EEN 162-1010
13. LCT EEN 37 A
14. LCT EEN 163 A
15. LCT EEN 158 G
16. MO 81
17. MOCORONGO
18. NA 682
19. NAPO 2
20. P-4-A
21. PA 107
22. PA 300
23. RB 46
24. SC 1
25. SIAL 93
26. SIAL 339
27. SPEC 54-1
28. UF 221
29. 125 C
30. 136 H

Appendix VII

Cocoa Hybrid Seeds delivered to DOAE

Date	From	No. of pods	No. of seeds
1/11/89	Chumphon Horticultural Research Centre	2,085	62,550
21/11/89	Chumphon Horticultural Research Centre	2,085	62,550
26/12/89	Chumphon Horticultural Research Centre	2,085	62,550
16/1/90	Chumphon Horticultural Research Centre	2,085	62,550
29/1/90	Chumphon Horticultural Research Centre	1,040	31,200
31/1/90	Trang Horticulture Research Station	1,045	31,350
21/2/90	Chumphon Horticultural Research Centre	2,085	62,550
9/3/90	Chumphon Horticultural Research Centre	2,085	62,550
21/3/90	Trang Horticulture Research Station	2,085	62,550
17/4/90	Chumphon Horticultural Research Centre	479	14,370
26/4/90	Trang Horticulture Research Station	2,741	83,430
23/1/91	Trang Horticulture Research Station	1,000	30,000
8/2/91	Chumphon Horticultural Research Centre	1,000	30,000
	TOTAL	21,940	658,200

1. Sub-Project Title : **Improvement of Apiculture and Bee Products (037)**

2. Responsible Agency :

2.1 Department of Agriculture
2.2 Department of Agricultural Extension
2.3 Chulalongkorn University
2.4 Kasetsart University
2.5 Chiangmai University
2.6 Khon Kaen University
2.7 King Mongkut's Institute of Technology Ladkrabang
2.8 Royal Forestry Department

3. Life of Project : 1988-1989

4. Implementation Sites : Nakhornratseema, Chantaburi Pitsanuloke, Chumporn, Chiangmai, Khonkaen, Lumpoon, Lopburi, Petchaboon, Nakornpatom, Chachoengsa , Prachinburi, Kanchanaburi and Burirum.

5. Approved Budget and Actual Expenditures :

	Approved budget		Actual Expenditures	
	Loan	Grant	Loan	Grant
5.1 DOA	103,454	3,200	88,320	
5.2 DOAE	109,277	6,400	89,224	
5.3 RFD	27,379	3,200	10,741	14,811
5.4 KU	38,558	3,200	23,532	
5.5 CMU	41,778	3,200	15,940	
5.6 CU	29,379	3,200	28,870	2,622
5.7 KKU	29,379	3,200	6,458	2,371
5.8 KMIT	27,379	3,200	17,027	3,050
TOTAL	406,583	28,800	280,112	22,854

Actual expenditures is approximately 70% of total budget.

6. Summary of Problems and Objectives :

A. Problems :

Honey bees yield four commercial products are honey, pollen, royal jelly and beeswax. The quality of these products needs to be improved to be more valuable. Most people accept that natural products from bees are good for health. These products are also exported primarily to Japan and Taiwan.

There are many limiting facters affecting on the success of beekeeping including bee diseases, predators and pests, residual toxicity of pesticides in bee products. Therefore, new technology on these factors has been tested and distributed to beekeepers and related honey processors.

B. Objectives :

1. To introduce the sources of bee pollen and bee pollination on economic fruit crops.
2. To introduce new control measures of honey bee mites using the latest chemicals.
3. To introduce ways to reduce pesticide residues in honey and other bee products.

7. Accompleshments :

7.1 DOA's responsibility

7.1.1 Study of kinds of flowers producing pollen which is rich in protein and available for honey bees in Pakchong located at Thanarat road, Musi subdistrict, Pakchong district, Nakornrat-

chasima province. It was found that 25 plant species were identified as pollen and/or nectar sources namely ***Ceiba pentandra, Bombax ceiba, Elaeocarpus hygrophilus, Zea mays, Aeschynomene americana, Tridax procumbens*** and ***Lagascea mollis.***

7.1.2 Introduction of European honey bee for pollination of rambutan in orchards at Thungbenja subdistrict, Thamai district, Chanthaburi province has been studied and 250 colonies were placed in rambutan orchards at the rate of 5 rai/colony (2 acre/col.). It was found that the yield of rambutan was increased and pesticide use and application time was decreased.

7.1.3 New chemical controls of honey bee mites were introduced. We recommend Fluvalinate for controlling the bee mites; Amitraz was the second choice but Amitraz should be alternated with other chemicals to avoid amitraz resistance in bee mites.

The pesticide residues of honey and other bee products has been detected by using GLC. About 133 samples of honey were analyzed. It was found that rambutan honey was contaminated with malathion at the level of 0.03 to 0.04 ppm. Carbofuran was also found in rambutan honey. Multiple pesticides were present in rambutan honey namely heptachlor and dieldrin at about 0.01 ppm. The pesticide mentioned have been banned for many years, but still are found in honey and other bee products.

To avoid the contamination by miticides the honey should be extracted after the use of miticides has been stopped for 2 weeks.

The Chemical composition analysis of honey was not different from U.S. standards.

7.2 DOAE's responsibility

DOAE studied on source of bee forage at Pitsanuloke Chantaburi and Chumporn and 24 items of bee forage are met. Five of Beekeeping Centers of DOAE provided technical assistance to beekeepers in areas of health checking and disease centrol service, 514 times/9,830 colonies.

Beekeeping Extension and training activities are as fallows :

1. Beekeeping training course to farmers, 10 times/450 farmers.
2. Extend bee colonies to farmers, 130 persons/357 colonies.
3. Extend queen bees to farmers, 263 persons/913 queens.

7.3 CU's responsibility

7.3.1 IDENTIFICATION OF SOME PHYSICAL PROPERTIES AND COMPOSITION OF HONEY AND BEE POLLEN PRODUCED FROM DIFFERENT FLORA

Honey and other bee products have been produced from various flora as one of the income sources in agriculture. The honey and bee pollen produced from different flora appear to be different in some properties and composition. We identified some of the physical properties and composition of honey and bee pollen produced from different flora as shown in the tables 2. It was found that pH, moisture content and reducing sugars were in the ranges of 4.1-6.0, 15-20% and 64-68%, respectively.

The results of this study give provide a guide to selection of high quality locations for bee hives.

7.3.2 IDENTIFICATION OF SOME PESTICIDE RESIDUES IN HONEY BEE POLLEN PRODUCED FROM DIFFERENT FLORA

The pesticide residues in honey and other bee products such as bee pollen vary depending on the flora on which the bee feeds. The amount of D-fructose, D-glucose, hydroxymethyl furfural and some pesticide residues are reported in table 1. The quantitative determination of the pesticide residues has been done by the method of Gas-Liquid Chromatography with the Flame Detector. It was found that malathion is the predominate pesticide residues in the honey samples. The results are shown in Tables 2.

7.3.3 EFFECTIVENESS OF SOME CHEMICAL AGENTS (APISTAN, BAVAROL, AND FORMIC ACID) FOR CONTROL OF THE BEE MITE ***TROPILAELAPS CLAREAE*** IN EUROPEAN HONEYBEE HIVES.

The efficiency of two trade products (Apistan, Bavarol) and formic acid were tested on control of the bee mite, ***Tropilaelaps clareae.*** The experimental design included 24 colonies infested with ***T. clareae.*** A random design (CRD) was given 4 treatments using 6 replicated (colonies). The effeciveness of Apistan, Bavarol and 65% Formic acid for the control of ***T. clareae*** were 63%, 53% and 30%, respectively (Table 4), all results were significantly from the control colonies ($P < 0.05$).

7.3.4 THE EFFECT OF THE CONTROL OF TROPILAELAPS MITE (TROPILAELAPS CLAREAE), ON TWO SPECIES OF HONEY BEE (APIS MELLIFERA AND APIS CERANA): CLEANING BEHAVIOR OF APIS CERANA.

Resistance of the Eastern honey bee (Apis cerana) to the Tropilaelaps mite (Tropilaelaps clareae) consists of a self cleaning, grooming dance, nestmate cleaning and group cleaning. About 72% of the mites were bitten resulting in their death and removed from the hive.

7.4 KU's responsibility

Bee colonies have been distributed to the North and Central Plain of Thailand for experiments. The migratory beekeeping is the best way to manage because the bee could have more food and the population could be increased at a faster rate. The main problem for the beekeeper is from the use of pesticides by farmers. In certain area that food source such as longan would cause problem in term of the over crowded of the bee hives.

By comparison, Chiang Dao seed to be the best area for the bee food source. The quantity of the food source and the environment were suitable for the setting of the hives. There were a greal deal of food sources all year round.

Pest control : ***Tropilaelaps*** mite had been found that it cause more problem than ***Varroa*** mite. The chemical treatment could be by using Folbex, V.A., Amitraz or Sulphur mixed with mothball. By alternating between chemical treatment and fumigant would be more effective.

7.5 KMIT's responsibility

KMIT found that Holy Basil using ground up leaves mixed with menthol crystal in a 1 : 1 ratio and placed under the bee combs as a fumigant is somewhat successful. Most of ***Varroa jacobsoni*** can be controled but ***Tropilaelaps*** can only be reduced a little.

Cyhalothrin L. mixed with menthol and water in the ratio of 1 : 3 : 19 respectively, offers fair protection. Only 1 c.c. of the solution placed in the queen cage under the bee comb for 10 days, the bee mite population is greatly inhibited. This mixture gets rid of bee mites without leaving toxic residue.

7.6 RFD's responsibility

One hundred honey be colonies were located in Northern and Northeastern areas of Forest Rehabilitant and Forest Village Development Projects. Plant survey were made in the 8 areas; 62 plant species were identified as shown in table 5. The most important species for bee forage in northern are longan, litchi, bitter bush and kapok. The main plant forage species for bees in northeastern are kapok, butter bush, eucalyptus and cassava.

Blooming periods of 62 plant species, shown in table 6, indicate that most of the species which produce plenty of pollen and nectar are blooming between December to March. Cash crops; rice, corn, beans and cassava were grown in each area which provided pollen or nectar over the year.

8. Benefits :

8.1 The locations of new bee forage sources has been extended to beekeepers.

8.2 The introduction of a mixture of Cyhalothrin L. menthol and water for fumigation which reduces the bee mite population without a toxic residue in a honey and other bee products. Honey bees can increase rapidly and thus increase production as mites are decreased.

9. Recommendations :

9.1 Additional surveys to locate suitable sources of bee forage are needed.

9.2 The control of bee mites requires added study.

Remark : No final report from CMU and KKU.

Table 1. Analysis of Honey in Thailand

Bee Flora (Honey Sources)	HMF (mg/kg)	Fruectose (%)	Glucose (%)	Hamidity No[1] (1985)	Hamidity No[2] (1986)	No 1[pH] (1985)	No 2 (1986)
Durian[1.2]	5.76	33.6	35.2	20.8	18.8	5.80	6.20
Eupatoria[1]	13.44	39.5	37.2	16.8	15.2	6.00	6.05
Lychee[3]	7.68	46.9	36.2	19.2	16.6	5.70	5.90
Mango[1.2]	7.68	40.4	43.5	18.8	16.2	5.10	4.55
Longan[3.4]	11.52	40.1	38.7	20.4	18.4	6.00	6.20
Kapok[4.5]	7.68	33.8	28.6	17.4	16.0	4.10	4.55
Havea[1.2]	1.92	39.5	35.9	21.2	20.4	4.80	5.40
Rambutan[1]	5.76	32.6	38.3	19.8	16.4	5.65	5.65
Citrus[1]	1.92	36.5	38.6	19.0	17.6	5.65	6.10

1. Trad Province 2. Chantaburi 3. Chieng mai 4. Pitsanulok 5. Uttaradit

Table 2. Chemical analysis of pollen in Thailand

Bee Flora	H_2O %	pH	Protein g/100g	Carotene mg/100g	Vitamin B1 mg/100g	Vitamin B2 mg/100g	Vitamin B3 mg/100g	Vitamin C mg/100g
Mimosa	10.50	4.30	22.60	0.10	0.56	0.60	12.41	7.09
Sunflower	11.00	3.40	25.17	0.08	0.56	4.11	6.64	8.91
Chili pepper	11.50	3.55	23.99	0.09	0.55	0.62	7.89	6.25
Corn	2.50	7.40	4.58	0.05	0.16	0.46	10.88	2.53
Kapok	6.44	7.20	17.45	0.05	0.47	0.47	5.82	5.43
Sesamum	3.00	6.50	22.43	0.04	1.13	3.02	10.99	13.15

Table 3. Analysis of pesticides residues in bee pollen

Sources of bee pollen	Insecticides	Residues	Maximum Residue Limits (MRL)
Fresh bee-pollen	methylparathion	1.56	0.2
	azodrin	6.83	–
	diazinon	5.32-5.81	0.5
	aldrin	8.77	0.02
Bee pollen Tablets	diazinon	2.42-3.35	0.5
	aldrin	0.59	0.02

Table 4. Comparison of experimental and control colonies (%)

Treatment	Percent control of *T. clareae*			
	week 1	week 2	week 3	week 4
1. Apistan[R]	33.00	63.20*	28.13	40.10
2. Bayvarol[R]	2.22	47.94	53.48*	44.86
3. Formic acid	5.89	9.29	1.12	29.50*

* Maximum percent control of ***T. clareae***

Table 5. Bee forage survey of 8 areas in the North and Northeast Regions

Scientific names	Species	Common name	Survey areas*							
			1	2	3	4	5	6	7	8
1. Acacia auriculaeformis Cunn.	Leguminosae	กระถินณรงค์	–	/	–	–	/	–	/	/
2. Acacia cutechu (L.f.) Willd	Leguminosae	สีเสียด	–	–	–	–	–	–	–	/
3. Albizia lobbeck (L.) Benth.	Leguminosae	พฤกษ์	–	–	–	–	–	/	–	–
4. Allium ascalonicum Linn.	Alliaceae	หอม	/	/	/	–	/	/	/	/
5. Amaranthus spinosus Linn.	Amaranthaceae	ผักขมหนาม	/	–	–	/	–	/	/	–
6. Azadirachta indica A. Juss	Meliaceae	สะเดา	–	/	–	–	/	–	/	/
7. Bombax ceiba Linn.	Bombacaceae	งิ้ว	–	–	–	–	/	/	–	–
8. Butea monosperma (Lmk) Taub.	Leguminosae	ทองกวาว	–	–	–	–	/	/	–	/
9. Caesalpinia enneaphylla Roxb.	Leguminosae	ขี้แรด	/	–	–	–	–	/	–	–
10. Caesalpinia pulcherrima Sw.	Leguminosae	หางนกยูงไทย	–	/	–	–	/	–	–	/
11. Capsicum Frutescens Linn.	Salanaceae	พริกขี้หนู	–	–	/	/	/	/	/	–
12. Carica papaya Linn.	Caricaceae	มะละกอ	–	–	/	/	–	–	/	/
13. Cassia fistula Linn.	Leguminosae	ชัยพฤกษ์	–	–	–	–	/	–	–	/
14. Cassia grandis Linn.	Leguminosae	กัลปพฤกษ์	–	–	–	–	–	/	–	–
15. Cassia siamea Britt.	Leguminosae	ขี้เหล็ก	/	–	–	–	/	/	/	/
16. Ceiba pentandra Gaerth.	Bombacaceae	นุ่น	/	/	–	–	/	/	/	/
17. Centrosema pubescens Benth.	Leguminosae	ถั่วลาย	–	–	–	–	–	–	/	/
18. Citrus aurantifolia Swing.	Rutaceae	มะนาว	–	/	–	–	/	/	–	–
19. Cochlospermum religiosum Alston	Bixaceae	สุพรรณิการ์	–	–	–	–	–	–	/	–
20. Cocos nucifera Linn.	Palmae	มะพร้าว	–	/	–	–	/	/	–	/
21. Cosmos sulfureus Car.	Compositae	ดาวกระจาย	–	/	–	–	–	–	/	/
22. Cucumis sativus Linn.	Cucurbitaceae	แตงกวา	/	–	–	/	–	/	–	/
23. Cucurbita moschata Poir.	Cucurbitaceae	ฟักทอง	–	/	–	–	/	/	/	–
24. Dalbergia cochinchinensis Pierre.	Leguminosae	พยูง	–	–	–	–	–	/	–	–
25. Delonix regia Rafin.	Leguminosae	หางนกยูงฝรั่ง	/	/	–	–	–	–	/	/
26. Dimocarpus Longan Lour.	Sapindaceae	ลำไย	/	–	–	–	–	–	–	–
27. Eucaliptus Camaldulensis Dehn.	Myrtaceae	ยูคาลิบตัส คามาลดูเลนซิส	/	–	–	/	/	–	/	/
28. Eucalyptus deglupta Blume.	Myrtaceae	ยูคาลิบตัส ดีกลุปต้า	–	–	–	–	–	–	–	/
29. Eupatorium odoratum Linn.	Compositae	สาบเสือ	/	/	/	–	/	/	/	/
30. Flaeourtia indica Merr.	Flacourtiaceae	ตะขบ	/	–	–	/	–	–	–	–
31. Gliricidin sepium Steud.	Leguminosae	แคฝรั่ง	–	–	–	–	–	–	/	–
32. Glycine max Merr.	Leguminosae	ถั่วเหลือง	–	/	/	–	–	–	–	/
33. Helianthus annuus Linn.	Compositaee	ทานตะวัน	–	–	/	–	–	–	–	–

Table 5. (Continue)

Scientific names	Species	Common name	Survey areas*							
			1	2	3	4	5	6	7	8
34. Leucaena leucocephala dr Wit.	Leguminosae	กระถิน	–	–	–	–	/	–	/	/
35. Linociera parkinsonii Hutch.	Oleaceae	มะเขือเปราะ	/	/	/	/	–	–	/	–
36. Litchi chinensis sonn	Sapindaceae	ลิ้นจี่	/	–	–	–	–	–	–	–
37. Lycopersicum esculentum Mill.	Solanaceae	มะเขือเทศ	–	–	–	–	–	–	–	/
38. Manihot esculenta Crantz.	Euphorbiaceae	มันสำปะหลัง	–	–	–	–	/	/	/	/
39. Mangifera indica Linn.	Anacardiaceae	มะม่วง	/	/	–	–	/	/	/	/
40. Melampodium paludosum HBK.	Compositae	กระดุมทอง	/	–	–	–	/	–	/	–
41. Mimosa pudica Linn.	Leguminosae	ไมยราบต้น	/	/	/	–	–	–	–	–
42. Mimosa invisa Mart.	Leguminosae	ไมยราบเลื้อย	–	–	–	/	/	/	/	/
43. Moringa oleifera Lamk.	Moringaceae	มะรุม	–	–	–	–	/	–	/	/
44. Ocimum canum Sims	Labiata	แมงลัก	–	/	–	/	–	–	–	–
45. Oryza sativa Linn.	Gramineae	ข้าว	–	/	/	–	/	–	–	–
46. Peltophorum dasyrachis Kurs.	Leguminosae	อะราง	–	/	–	–	–	–	/	–
47. Peltophorum pterocarpum Back.	Leguminosae	นนทรี	–	/	–	–	/	–	–	/
48. Pithecellobium dulce Roxb.	Leguminosae	มะขามเทศ	–	/	–	–	/	/	/	–
49. Pterocarpus macrocarpus Kurz.	Leguminosae	ประดู่	–	/	–	–	/	/	/	/
50. Ricinus communis Linn.	Euphorbiaceae	ละหุ่ง	–	–	/	/	/	/	/	–
51. Samanea saman Merr.	Leguminosae	จามจุรี	–	/	–	–	/	/	/	/
52. Sesamum indicum Linn.	Podaliaceae	งา	–	/	/	–	/	/	–	–
53. Sesbania gradiflora Poir.	Leguminosae	แคบ้าน	/	–	–	–	/	/	/	–
54. Setaria italica Beauv.	Gramineae	ข้าวฟ่าง	–	–	–	–	/	–	/	–
55. Solanum torvum Sw.	Solanaceae	มะเขือพวง	–	–	/	/	/	/	/	/
56. Tagetes erecta Linn.	Compositaee	ดาวเรือง	–	–	/	/	–	–	–	–
57. Tamarindus indicum Linn.	Leguminosae	มะขาม	–	–	–	/	/	–	–	/
58. Tectona Grandis Linn.f.	Verbenaceae	สัก	–	/	–	–	–	–	–	–
59. Tridax procumbens Linn.	Compositaee	ตีนตุ๊กแก	–	–	–	–	/	/	/	–
60. Vigna radiata (L.) Wilezek	Leguminosae	ถั่วเขียว	/	/	/	–	–	–	/	–
61. Xylia Xylocarpa Taub.	Leguminosae	แดง	/	–	–	–	/	–	–	–
62. Zea mays Linn.	Gramineaeae	ข้าวโพด	/	/	/	/	/	/	/	/

Table 6. Blooming periods of 62 plant species.

Scientific names	Species	Common name	Blooming periods												Pollen	Honey
			JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
1. Acacia auriculaeformis Cunn.	Leguminosae	กระถินณรงค์													/	–
2. Acacia cutechu (L.f.) Willd	Leguminosae	สีเสียด													/	–
3. Albizia lobbeck (L.) Benth.	Leguminosae	พฤกษ์													/	–
4. Allium ascalonicum Linn.	Alliaceae	หอม													/	/
5. Amaranthus spinosus Linn.	Amaranthaceae	ผักขมหนาม													/	–
6. Azadirachta indica A. Juss	Meliaceae	สะเดา													/	/
7. Bombax ceiba Linn.	Bombacaceae	งิ้ว													/	/
8. Butea monosperma (Lmk) Taub.	Leguminosae	ทองกวาว													/	/
9. Caesalpinia enneaphylla Roxb.	Leguminosae	ขี้แรด													/	–
10. Caesalpinia pulcherrima Sw.	Leguminosae	หางนกยูงไทย													–	/
11. Capsicum Frutescens Linn.	Salanaceae	พริกขี้หนู													/	–
12. Carica papaya Linn.	Caricaceae	มะละกอ													/	–
13. Cassia fistula Linn.	Leguminosae	ชัยพฤกษ์													/	–
14. Cassia grandis Linn.	Leguminosae	กัลปพฤกษ์													/	–
15. Cassia siamea Britt.	Leguminosae	ขี้เหล็ก													/	–
16. Ceiba pentandra Gaerth.	Bombacaceae	นุ่น													/	/
17. Centrosema pubescens Benth.	Leguminosae	ถั่วลาย													/	–
18. Citrus aurantifolia Swing.	Rutaceae	มะนาว													/	/
19. Cochlospermum religiosum Alston	Bixaceae	สุพรรณิการ์													/	–
20. Cocos nucifera Linn.	Palmae	มะพร้าว													/	/
21. Cosmos sulfureus Car.	Compositae	ดาวกระจาย													/	–
22. Cucumis sativus Linn.	Cucurbitaceae	แตงกวา													/	/
23. Cucurbita moschata Poir.	Cucurbitaceae	ฟักทอง													/	–
24. Dalbergia cochinchinensis Pierre.	Leguminosae	พยูง													/	/
25. Delonix regia Rafin.	Leguminosae	หางนกยูงฝรั่ง													/	–
26. Dimocarpus Longan Lour.	Sapindaceae	ลำไย													/	/
27. Eucaliptus Camaldulensis Dehn.	Myrtaceae	ยูคาลิบตัส คามาลดูเลนซิส													/	/
28. Eucalyptus deglupta Blume.	Myrtaceae	ยูคาลิบตัส ดีกลุปต้า													/	/
29. Eupatorium odoratum Linn.	Compositae	สาบเสือ													/	/
30. Flaeourtia indica Merr.	Flacourtiaceae	ตะขบ													–	/
31. Gliricidin sepium Steud.	Leguminosae	แคฝรั่ง													/	–
32. Glycine max Merr.	Leguminosae	ถั่วเหลือง													/	/
33. Helianthus annuus Linn.	Compositaee	ทานตะวัน													–	/
34. Leucaena leucocephala dr Wit.	Leguminosae	กระถิน													/	–

Table 6. (Continue)

Scientific names	Species	Common name	Blooming periods												Pollen	Honey
			JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
35. Linociera parkinsonii Hutch.	Oleaceae	มะเขื่อเปราะ													/	–
36. Litchi chinesis Sonn.	Sapindaceae	ลิ้นจี่													/	/
37. Lycopersicum esculentum Mill.	Solanaceae	มะเขื่อเทศ													/	–
38. Manihot esculenta Crantz.	Euphorbiaceae	มันสำปะหลัง													/	/
39. Mangifera indica Linn.	Anacardiaceae	มะม่วง													/	/
40. Melampodium paludosum HBK.	Compositae	กระดุมทอง													/	–
41. Mimosa pudica Linn.	Leguminosae	ไมยราบต้น													/	–
42. Mimosa invisa Mart.	Leguminosae	ไมยราบเลื้อย													/	–
43. Moringa oleifera Lamk.	Moringaceae	มะรุม													/	/
44. Ocimum canum Sims	Labiata	แมงลัก													/	/
45. Oryza sativa Linn.	Gramineae	ข้าว													/	–
46. Peltophorum dasyrachis Kurs.	Leguminosae	อะราง													/	–
47. Peltophorum pterocarpum Back.	Leguminosae	นนทรี													/	–
48. Pithecellobium dulce Roxb.	Leguminosae	มะขามเทศ													/	–
49. Pterocarpus macrocarpus Kurz.	Leguminosae	ประดู่													/	/
50. Ricinus communis Linn.	Euphorbiaceae	ละหุ่ง													/	/
51. Samanea saman Merr.	Leguminosae	จามจุรี													/	–
52. Sesamum indicum Linn.	Podaliaceae	งา													/	/
53. Sesbania gradiflora Poir.	Leguminosae	แคบ้าน													/	/
54. Setaria italica Beauv.	Gramineae	ข้าวฟ่าง													/	–
55. Solanum torvum Sw.	Solanaceae	มะเขื่อพวง													/	/
56. Tagetes erecta Linn.	Compositaee	ดาวเรือง													/	–
57. Tamarindus indicum Linn.	Leguminosae	มะขาม													/	/
58. Tectona Grandis Linn.f.	Verbenaceae	สัก													/	–
59. Tridax procumbens Linn.	Compositaee	ตีนตุ๊กแก													/	–
60. Vigna radiata (L.) Wilezek	Leguminosae	ถั่วเขียว													–	/
61. Xylia Xylocarpa Taub.	Leguminosae	แดง													/	/
62. Zea mays Linn.	Gramineaeae	ข้าวโพด													/	–

Fig. 1 Grooming behavior of *A. cerana* cleaning to bite bee mite

Fig. 2 An abnormal bee mite was found after cleaning

1. Sub-Project Title : **Technology of Hybrid Silkworm Egg Production by Seed Area System (038)**

2. Responsible Agencies : Department of Agricultural Extension
Department of Agriculture and Kasetsart University

3. Life of Project : 1989-1990

4. Implementation Sites : Srisaket, Nakornratchasima, Buriram and Nakhonpratom

5. Approved Budget :

		Loan	Grant	Sub-Total
Dept. of Agri. Ext.	US $	58,358	5,254	63,612
Dept. of Agri.	US $	69,011	5,254	74,265
Kasetsart University	US $	83,790	5,254	89,044
Total			**US $**	**226,921**

6. Actual Expenditure : **US $ 214,780 or approximately 95% of approved budget**

7. Summary of Problem and Objectives :

A. Problem :

About 90% of Sericulturists in Thailand still rear the native silkworm because the risk and investment are quite low. Farmers also like to produce silkworm cocoons themselves. The results are low quality and quantity of silk yarn which must be used at home and cannot be used on high speed looms. In addition, the government cannot supply the hybrid silkworm cocoons to the farmers in sufficient quantities. Only 1% of hybrid silkworm cocoons can be provided to the farmers. The rest have had to be imported. Because of these problems, Royal Thai Government has a policy to enhance hybrid silkworm cocoon production in which the private sector participates. About 20% of silkworm cocoons will be produced by government sericulture centers, using the seed area system and 80% will be produced by the private sector. With this method, it is believed that the domestic supply of hybrid silkworm cocoons can meet domestic demand.

The Seed Area System is started by selecting capable villagers and efficient farmers who would like to join the project. These farmers should be trained in Sericulture before joining the project. Department of Agriculture and Kasetsart University together produce parent stock and give these cocoons to the 3 sericultural extension centers of Department of Agricultural Extension where parent stock will be multiplied to certified cocoons for distribution to farmers. Farmers who participate in the project rear these silkworm cocoons under the close supervision of government officers. The farmers sell their cocoon production to sericulture extension centers and the centers use the cocoons to breed and produce other silkworm cocoons.

B. Objectives :

1. To increase the quantity of good hybrid silkworm cocoons for farmers.
2. To transfer silkworm cocoon production techniques from sericulture stations or centers to government officers, farmers, and the private sector.
3. To increase the quantity of domestic hybrid silkyarn and decrease the imported cocoons and silk yarn.

8. Accomplishments :

Department of Agriculture

1) Research on Pureline hybrid Silkworms genetics including selection, improvement, purification and maintaining the varieties, such as.

– K_1 variety which has been improved and purified from N. 124 × C 124 (one-way F_1

hybrid from Japan). Select and purify to get pure lines which have a shape similar to purelins from Japan. Good characteristics: the number of silkworm eggs is approximately 432/moth; cocoon shell percentage 16.9%; percent of completed pupae 86.0% and fresh cocoon weight is 1.43 gm.

– K_{13} variety which has been improved and purified from F_1 hybrid of $K_9 \times K_1$ until a pure line results. The number of silkworm eggs is 429/moth; cocoon shell percentage 20.4%; percent of completed pupae 91.5% and fresh cocoon weight is 1.38 gm.

– K_9 variety which has been improved and purified from F_1 hybrid of Kinshu × Showa 2 × K_1 until a pure line results. The number of silkworm eggs is approximately 415/moth; cocoon shell percentage 21.1%; percent of completed pupae 89%; and fresh cocoon weight is 1.52 gm.

– K_8 variety which has been improved and purified from C 134 variety until a pure line (Chinese) results. The number of silkworm eggs. is 469/moth; cocoon shell percentage 19.0%; percent of completed pupae 92.0%; and fresh cocoon weight is 1.67 gm.

– K_{18} variety which has been improved and purified from $K_6 \times K_8$ hybrid until a pure line (Chinese) results. The number of silkworm egg is 450/moth; cocoon shell percentage 21.6%; percent of completed pupae 10.9%; and fresh cocoon weight is 1.35 gm.

– K_5 variety which has been improved and purified from Shungri × Shogetsu hybrid until a pure line (Chinese) results. The number of silkworm egg is 480/moth; cocoon shell percentage 21.3%; percent of completed pupae 92.5%; and fresh cocoon weight is 2.07 gm.

– UB_1 variety which has been select from Guangnong No. 3 hybrid until a pure Thai variety (Japanese) results. The number of silkworm egg is 354/moth; cocoon shell percentage 17.8%; percent of completed pupae 17.8%; percent of completed pupae 92.5%; and fresh cocoon weight is 1.10 gm.

– Nang Noi variety which has been collected from farmers and selected until a pure Thai variety results. The numbers of silkworm egg is 250/moth; cocoon shell percentage 12.8 - 13.5%; and fresh cocoon weight is 0.08 gm.

– Nang Lai which has been selected until a pure Thai variety results. The number of silkworm egg is 320 - 350/moth; cocoon shell percentage 12.5 - 13%; cocoon shell weight is 0.71 gm.

2) Research on Hybrid silkworms is aimed at finding good hybrid varieties and the result show that :

– for a bivoltine race, the hybrid of $K_1 \times K_8$ can produce the highest Yield, about 20 - 30 kg/box, silkworm age 20 - 25 days the number of cocoon/kilogram is 63 cocoon/kg.

– for polyvoltine × bivoltine, the hybrid of Nang Noi × UB_1 or "Dok Bua" variety can produce the highest yield. The cocoon shell percentage is 15.3% and fresh cocoon weight is 1.59 gm.

Kasetsart University With the Sericultural Extension Center III, Buriram province, tried to find the best hybrid variety which can produce the highest yield by rearing grand parent stock such as BK_1, BK_2, KM_8 and TH_{14} and crosses between $BK_1 \times BK_2$, $BK_1 \times TH_{14}$, $BK_2 \times TH_{14}$ and $KM_8 \times TH_{14}$. These varieties were given to 12 farmers at Ban Preum Pattana Village, Nang Rong District, Buriram Province. Each of the farmers reared 56 moths. During the rearing period, the farmers were under agricultural extension officers' direct control.

Result show that the hybrid of $TH_{14} \times KU_8$ has the most vigor and the least percentage of uncompleted cocoons. Moreover, cocoon shell percentage and fiber lenght of this hybrid showed very satisfactory results. The hybrid of $BK_1 \times BK_2$ produced the highest number of cocoons but they were the least vigorous.

Table 1. The means of 7 characteristics of the hybrid cocoons

Variety	the weight of 10 grown larvae	% of bad cocoons	% of completed larvae	No. of cocoons per litter	cocoon shell percentage	Average length of the fiber (m)	size of the fibers (denier)
TH 14 × BK 1	24.74	6.91	85.64	112	16.20	668.31	2.00
TH 14 × BK 2	24.96	6.98	84.07	111	15.90	657.08	1.98
TH 14 × KU 8	26.11	5.12	86.19	109	16.52	687.24	2.05
BK 1 × BK 2	26.59	12.69	80.03	107	17.41	736.90	1.96

Department of Agricultural Extension

The responsibilities of Department of Agricultural Extension are to get grand parent seed from Department of Agriculture and Kasetsart University and multiplied this certified seed by :

1. Sericultural Extension Center I produces certified seed and distributes to farmers in Ubonratchathani, Mukdahan and Nakhon Phanom provinces.

2. Sericultural Extension Center II produces certified seed and distributes to farmers in Nakhonratchasima and Loei provinces.

3. Sericultural Extension Center III produces certified seed and distributes to farmers in Buriram, Surin and Mahasarakam provinces.

Accomplishments :

1) Selected villages and farmers for hybrid cocoon production by the Seed Area System :

– Sericultural Extension Center I selected 10 farmers at the implementation site at Ban Keeka village, Utompornpisai district, Srisaket province.

– Sericultural Extension Center II selected 10 farmers at the implementation site at Ban Nong Mow, Khonburi district, Nakhonratchasima province.

– Sericultural Extension Center III selected 10 farmers at the implementation site at Ban Preum Pattana, Prakham district, Buriram province.

2) Selected three officers, one each from Department of Agricultural Extension, Department of Agriculture and Kasetsart University to participate in "Technology of hybrid silkworm Production by the Seed Area System's training Course" at Suwon City, Republic of Korea during september 28 - October 11, 1989.

3) Farmers' Training : Department of Agricultural Extension selected 315 farmers to train on Sericulture Techniques for 30 days at Sericultural Extension Centers and 3,400 farmers have been trained in their villages.

4) Officers' Training : Department of Agricultural Extension has trained 400 officers at Sericultural Extension Center III Buriram on Sericultural Technologies and Techniques.

5) Hybrid Silkworm Cocoon Services by Sericultural Extension Centers : The three centers reared the young silkworms until 2nd instar stage after that distributed to 10 farmers in each center's area to rear until the silkworm produced cocoons. After that the farmers sold the cocoons to the centers.

Numbers of sheets of silkworm cocoons that the three centers produced were as follows ;

– Sericultural Extension Center I Srisaket produced 18,000 sheets.
– Sericultural Extension Center II Nakhonratchasima produced 18,000 sheets.
– Sericultural Extension Center III Buriram produced 18,000 sheets.

Total 54,000 sheets

6) Technique for producing Silkworm Pupae by use of the "Seed Area" system :

A) Procedures

Investigations on silkworm varieties selection improvement using inbred lines were as follows :

– Variety K1 was evolved from a single cross hybrid N124 × C124 which was screened for progeny with the characteristics of the Japanese race K1 Variety is suitable as parent for producing hybrids.

– Variety K13 was evolved from K9 × K1 after screening for progeny with characteristics of the Japanese race. It is suitable as parent for producing hybrids.

– Variety K9 was evolved from (Kinshu × showa) × K1 after screening for the characteristics of the Japanese race. It is suitable as parent stock for hybrids production.

– Variety K8 was evolved from C134 after screening for characteristics of the Chinese race. It is suitable for hybrids production.

– Variety K18 was evolved from K6 × K8 after screening for characteristics of the Chinese race. It is suitable as parent stock for hybrids production.

– Variety UB1 was evolved from "Guang Nong number 3" after screening for characteristics. The progeny have uniform characteristics. Crosses with Thai varieties have led to promising progeny.

– Variety KS was evolved from Shunrei × Shogetsu after screening for characteristics of the inbred line of Chinese race. The experiment is in progress.

– Nangnoi variety was evolved from breed stock from village sericulturists. Progeny was screened for characteristic of indigeneous varieties with resistance to high temperature (40°-41°C.). The Nang noi variety is the consequence breed stock was collected from Ban Noi Tambon Yang, Amphur Muang, Buriram province.

– Nanglai variety breed stock was collected from Ban Na Sam, Tambon Na Bua, Amphur Muang, Surin province. The original variety Surin Nanglai had a white cocoon. the present variety Nanglai, has been collected as an inbred line with yellow cocoon colour.

B) Investigation on hybridization of Individuals of different inbred races bred for high cocoon production and to produce eggs of varieties which Department of Agricultural Extention can use in extension activities.

– Results of research hybridization the crosses K1 × K8 or K8 × K1 and Nang noi × UB1 (DOKBUA) gave the best results.

– K1 × K8, under recent technologies this crosses produce 20 Kgs. of cocoon per boxes (from not less than 20,000 eggs) with a value of 100 Baht per kilogram of fresh weight. Although quality and quantity are good, the colour of the filament is white and is not well accepted on the market.

– Nangnoi × UB1, this variety has been tested with sericulturists. It is healthy gives good yield and is accepted by sericulturists. The reel ability is good, yellow filament yarn. The larvae is stout, yields average 40% higher than for local veriety.

C) Varieties for extension

K1	169	sheets or	10,140	batches
K8	169	〃	10,140	〃
UB1	230	〃	13,800	〃
Nangnoi	230	〃	13,800	〃

– K1 and K8 was produced at Nakorn Ratchasima Sericultural Research and Training Center.

– UB 1 and Nangnoi was produced at Ubonratchathani Sericultural Experiment Station.

– All four have been sent to Department of Agricultural Extension in order to produce hybrid eggs for distribution to sericulturists.

9. Benefits of the Project :

Presently there are several private firms producing bivoltine silkworm eggs :

– Thai Silk Products Co., Ltd. is using the Seed Area System in Nakhonratchasima province based on the methods of the ATT pilot project which showed satisfactory results.

– Chul Thai Silk Co., Ltd. is also using Seed Area System in Petchaboon province. In the future, this firm might be the largest company in produce bivoltine silkworm eggs.

– U-Thai International Co., Ltd. is studying the feasibility of silkworm egg production by Seed Area System and is expected to invest.

In the future, it is hope that farmers in Thailand will be able to use domestic hybrid silkworm eggs. They will have more than 54,000 sheets of eggs worth at least US $ 240,000 or enough hybrid silkworm eggs to meet the demand for 1 year. The cocoon yield will be not less than 972,000 kgs, worth more than US $ 3.9 million. Weft silk has been increased more than 80,000 kgs. The first year as a result of the ATT subproject.

10. Recommendation :

This project lasted two years (1989 - 1990) Especially for breeding new varieties this time was very short; it sometimes takes ten years to produce good new varieties. Great care must be taken in maintaining the purity of the various lines.

For Silkworm "egg" production continuous research to improve varieties is essential to find suitable new replacement varieties. Research personnel are needed who can maintain the purity of the silkworm lines so that they can be used as parent stock for as long as possible.

Cocoons cutting and pureline hybrid silkworms selection

Silkworm Insemination